



PHD

Determinants of Health and Wellbeing Among Fire and Rescue Personnel

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This thesis is the product in part of the research collaboration between the Chief Fire Officers Association (CFOA) and the University of Bath. The project team was comprised of Professor James Bilzon, Professor Martyn Standage, Dr Andrew Siddall, Philip Turner, Richard Stevenson.

The University of Bath/CFOA research collaboration had two main aims:

- 1. Investigate the health characteristics, lifestyle behaviours and psychological wellbeing of UK Fire and Rescue Service employees.***
- 2. Investigate minimum cardiorespiratory and muscular strength requirements for safe and effective firefighting and an appropriate role-based assessment.***

This thesis includes the investigative results from the first of the above project aims. Professor James Bilzon was the supervising researcher and principle investigator for the project. Dr Andrew Siddall provided clinical expertise in the collection of blood samples, laboratory analysis and data analysis support. Richard Stevenson assisted in the collection of blood samples.

Philip Turner principally designed the lifestyle questionnaire, including also the acquisition, analysis and interpretation of all data included in this thesis.

Philip Turner was responsible for the writing of the thesis. Dr Andrew Siddall and Professor James Bilzon and Professor Martyn Standage provided critical feedback and corrections for the final version of the thesis.

Determinants of Health and Wellbeing Among Fire and Rescue Service Personnel

Philip James Frank Turner

A thesis submitted for the degree of Doctor of Philosophy

University of Bath

Department for Health

JULY 2018

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Abstract

Physical inactivity and shift work are risk factors for cardiovascular disease. UK Fire and Rescue Service (FRS) employees are engaged in job roles that differ in their physical activity and shift working requirements: operational firefighters (FF), emergency control (EC), and administrative support (AS) workers. Emergency response involves unpredictable periods of intense physical and psychological arousal that are associated with increased risk of cardiac event. The aim of this body of research was to investigate the health characteristics, lifestyle behaviours and wellbeing of three FRS occupational groups and describe the CVD risk profile of a UK FF sample. The first study established significantly higher physical activity and lower sedentary behaviour and hypertension prevalence in FF compared to EC and AS. However, despite these lifestyle differences, sleep behaviours and self-rated health were found to be independent determinants of psychological wellbeing irrespective of FRS job role (Study 2). The FF respondents were classed into low, moderate and high CVD risk groups, such that FF classed as being at a low CVD risk reported the highest physical activity, perceived wellbeing (life satisfaction; depression, anxiety, and stress), and lowest daily sitting time (study 3). Further analysis in a smaller cohort of FF (study 4) found that systemic biomarkers of cardiometabolic risk were significantly higher among FF that were classed as moderate CVD risk, compared to low CVD risk. FRS health professionals may improve intervention outcomes by including self-rated health and sleep behaviours in annual health screening assessments, whilst also interpreting objective markers of cardiometabolic health status. In comparison to other FRS job roles, FF present on average as a healthier population. However, a significant group of FF are at an increased risk of CVD and would likely benefit from targeted lifestyle intervention.

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Abbreviations

ACSM	American College of Sports Medicine
AS	Administrative Support
AUDIT-C	Alcohol Use Identification Test
ANOVA	Analysis of Variance
BF%	Body Fat Percentage
BMI	Body Mass Index
BM	Body mass
CFOA	Chief Fire Officers Association
CHD	Coronary Heart Disease
CRP	C-reactive Protein
CVD	Cardiovascular Disease
DAS-21	Depression Anxiety and Stress Scale
EC	Emergency Control
ESS	Epworth Sleepiness Scale
FM	Fat mass
FF	Firefighter
FRS	Fire and Rescue Service
HDL-C	High-density lipoprotein cholesterol
IL-6	Interleukin-6
IPAQ	International Physical Activity Questionnaire
LDL-C	Low-density lipoprotein cholesterol
METS	Metabolic Equivalents
NEFA	Non-Esterified Fatty Acids

PA	Physical Activity
PANAS	Positive and Negative Affect Scale
PSQI	Pittsburgh Sleep Quality Index
SRH	Self-rated Health
SWLS	Satisfaction with Life Scale
TC	Total cholesterol
TG	Triglycerides
TNFα	Tumor Necrosis Factor α

CHAPTER 1

General Introduction

1.1 General Introduction

The health and prevalence of disease in populations engaged in different occupations has been an epidemiological curiosity since ancient times. For example it is perhaps not surprising to note that Egyptian labourers tasked with building the Great Pyramids were short-lived by comparison with Egyptian priests (Brandt-Rauf & Brandt-Rauf, 1987; Jouanna, 2012). It is to be expected that the modern work environment is much safer and less hazardous than in ancient times (HSE, 2017). Yet, it is surprising to consider that over two thousand years later such health inequalities persist both between occupations (Acheson et al., 1998; Black, Morris, Smith, & Townsend, 1980) and within occupations (Marmot, Rose, ShIpley, & Hamilton, 1978). Government reports have identified the important role of the workplace in preventing chronic disease, promoting wellbeing and early identification and intervention for health-related conditions (Black, 2009). However the findings of a number of government reports have not been well received by policy makers (Court, 1981; Morris, 1980), not least because of the challenging and wide ranging socioeconomic drivers of health inequalities (Marmot et al., 2010). Yet health is also influenced by the intrinsic requirements of the modern work environment. Shift working and physical activity are two factors that vary between occupations and considered influential for health outcomes (Atkinson & Davenne, 2007)

Shift work has been extensively cited as an occupational stressor associated with chronic disease and unhealthy lifestyles (Department of Health, 2014) with behavioural (Fullick et al., 2009) and physiological consequences (Antunes, Levandovski, Dantas, Caumo, & Hidalgo, 2010; Buxton et al., 2012). The behavioural consequences of shift work include a propensity towards poorer health habits among shift workers (KivimÄki et al., 2001), including smoking (Vyas et al., 2012), increased sedentary behaviour (Hulsegge et al., 2017) and changes to eating behaviour (Lowden, Moreno, Holmbäck, Lennernäs, & Tucker, 2010; Waterhouse, Buckley, Edwards, & Reilly, 2003). Research regarding the physiological consequences of shift work has cited commonalities to that of insufficient sleep, including adverse metabolic adaptations and

increasing risk of obesity (Buxton & Marcelli, 2010; Kecklund & Axelsson, 2016) and chronic disease (Vyas et al., 2012). Although the proposed causal pathways linking chronic disease and shift work are yet to be established (Puttonen, Harma, & Hublin, 2010), studies that have adjusted for unhealthy behaviours in shift workers continue to report an increase in risk (Haupt et al., 2008; Kawachi et al., 1995).

Physical activity offers a myriad of health benefits (Nocon et al., 2008) including protection from chronic disease (Warburton, Nicol, & Bredin, 2006) such as to be comparable to a drug intervention (Vina, Sanchis-Gomar, Martinez-Bello, & Gomez-Cabrera, 2012). The work environments that frustrate or necessitate physical activity behaviours (Coenen et al., 2018), may present an opportunity to compare employees engaged in differing job roles. Recently the adverse health consequences of workplace sedentary behaviours typical of the modern office environment has been the focus of research (Buckley et al., 2015) and prompted discussions on quantitative guidelines (Stamatakis et al., 2018) similar to those for physical activity (Bull et al., 2010).

Occupation is thought to affect health outcome not only by the risk and nature of the job tasks carried out but by influencing the health behaviours of employees (Murphy, Bond, Beaton, Murphy, & Johnson, 2002). Engaging in healthy behaviours that include non-smoking, moderate alcohol, avoidance of physical inactivity and consumption of fruit and vegetables, on average imparts a 4-fold difference in mortality compared to those who engage in none (Khaw et al., 2008). Determining the consequences for health and wellbeing for employees engaged in dynamic and unpredictable work environments presents a challenge for researchers (Tsigas, Panagopoulou, & Niakas, 2015; Wesemann et al., 2018). A higher prevalence of musculoskeletal disorders, chronic disease and psychological disorders (Fullerton, Ursano, & Wang, 2004; Guidotti, 1992) are reported among emergency responders compared to other occupations.

UK Fire and Rescue Service (FRS) employees are engaged in job roles that differ in their shift working and physical fitness requirements (Siddall, Stevenson, Turner, Stokes, & Bilzon, 2016), which may have consequences for employee health and wellbeing. Yet the health characteristics and lifestyle behaviours of employees engaged in differing job roles within the UK FRS is

unclear and as such the consequences for psychological wellbeing are not known. Few studies have investigated the health risks if any associated with firefighting among UK FRS employees. A systematic review of non-cancer health risks in firefighters did not identify any increase in disease or ill health outcomes (Crawford & Graveling, 2012). These findings may be confounded by exclusion of firefighters identified with ill health through periodic medicals. Yet a high prevalence of CVD risk factors, including obesity and high blood pressure is reported among US firefighters (Byczek, Walton, Conrad, Reichelt, & Samo, 2004; Poston et al., 2011) and compared to non-obese firefighters, obese firefighters are at an increased risk of hypertension (Soteriades, Kales, Liarokapis, & Christiani, 2003) and job disability (Soteriades, Hauser, Kawachi, Christiani, & Kales, 2008). Furthermore, obese firefighters are reported to be at a higher risk of cardiac abnormalities (Al-Zaiti & Carey, 2015). Left ventricular hypertrophy is associated with increased cardiac event risk in firefighters and has been implicated in on-duty cardiac event death (Soteriades, Targino, et al., 2011). Furthermore in a cohort of US firefighters, exercise stress testing identified approximately one third as abnormal electrocardiogram results requiring further investigation (Al-Zaiti & Carey, 2015).

Emergency response activities are understood to be physically and psychologically demanding and unpredictable in nature (Stevenson, Siddall, Turner, & Bilzon, 2017) and sudden bouts of strenuous physical activity can result in cardiac abnormalities (Barnard, Gardner, Diaco, MacAlpin, & Kattus, 1973). Previous research among US firefighter populations indicates that the physiological and psychological arousal of emergency response predisposes some firefighters to increasing risk of cardiac event (Kales, Soteriades, Christophi, & Christiani, 2007), in particular those that smoke, have hypertension and a prior history of cardiovascular disease (CVD) (Farioli et al., 2014; Geibe et al., 2008). However, it is unclear to what extent unhealthy lifestyle behaviours and health characteristics associated with CVD are manifest within UK firefighter populations. As such, determining the health profile of the UK FRS and making between job role comparisons may prove useful to health professionals aiming to identify and understand at risk groups within the organisation. Further understanding the role-specific CVD risk profile of

operational firefighters may inform intervention programs and help mitigate any increase in cardiac risk associated with emergency response. To date no research has examined the lifestyle and wellbeing of employees engaged in differing job roles within the UK FRS. The firefighter (FF) role includes emergency response activity as defined by responding to, and attending, emergency incidents, associated maintenance of a minimum physical fitness standard and are shift working; emergency control (EC) role includes emergency call handling, are typically office-based and shift working; and administrative support (AS) role is administrative, office-based and typically non-shift working.

Figure 1.1 illustrates the different job roles within the UK FRS and presents the intended focus for the experimental chapters within this thesis. Study one will aim to describe the health characteristics and lifestyle behaviours of the study population (UK Fire & Rescue employees) according to predefined job roles and test for between group mean differences in health, lifestyle and wellbeing. Study two investigates the main determinants of psychological wellbeing among FRS employees. Studies three and four focus on the FF role. In Chapter three the FF sample is grouped according to predicted CVD risk and between groups comparisons are made for health, lifestyle and wellbeing. Chapter four combines objective markers of health and blood sample results from a cohort of FF and groups the sample according to CVD risk. Between groups comparisons are made for markers of inflammation and lipids. Further analysis is made by comparing inflammatory biomarker concentrations and lipids between FF grouped into upper and lower quartiles of adiposity.

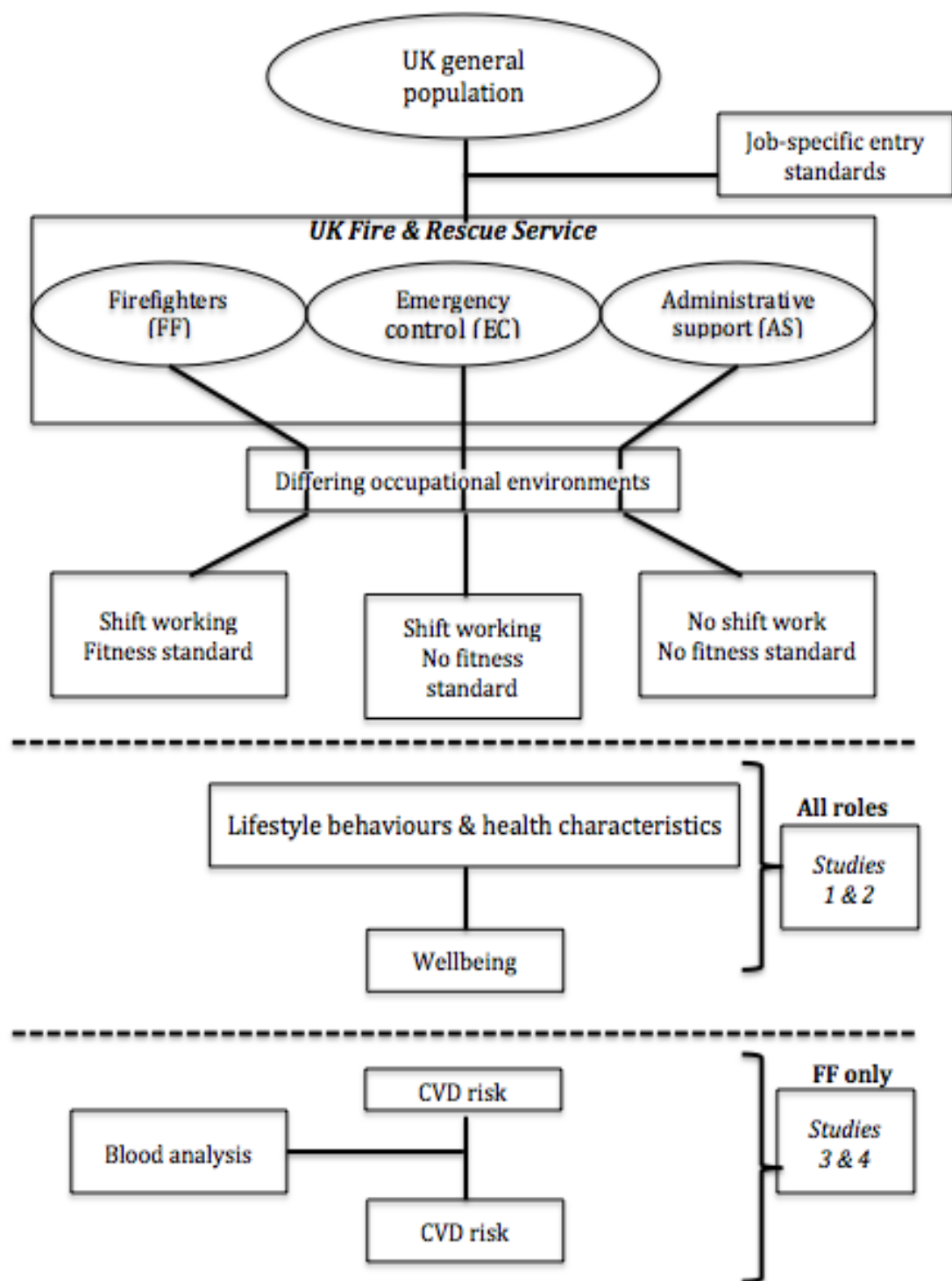


Figure 1.2 Schematic overview of study design

CHAPTER 2

Review of literature

Review of Literature

2.1 Occupation and health; historical context

There are considered two historical suspects of disease causation; that from within and described as the imbalance of humours and that from without and described with such religious vigor as being an attack by demons (Seaton, 2014). This opinion, although steeped in superstition, still relied on a degree of experimentation and observation yet the interpretation resulted in promoting such remedies as blood-letting, which continued for almost 2000 years. An attack by demons was perhaps an early acknowledgement of the pivotal role played by the environment in wellbeing; recognised by Hippocrates as important in his teaching of disease transmission, nutrition and psychological wellbeing (Jouanna, 2012). Hippocrates, recognised in modern medicine by the use of the Hippocratic Oath, is considered to be the founder of ancient medicine and his philosophical approach is perhaps acknowledged in the widely researched field of self-rated health.

The Greek physician, Galen, considered to be one of the most prominent medical researchers of antiquity, expanded the work of Hippocrates and promoted the miasma theory of disease such that infection was spread by means of polluted, foul air (Hankinson, 2008). Although some of Galen's theories have since been disregarded, he used the term 'polisarkia' to describe morbid obesity and prescribed changes to diet and exercise, are lifestyle modifications with much relevance for modern medicine (Papavramidou, Papavramidis, & Christopoulou-Aletra, 2004).

The ancient Egyptians were early observers of the impact of occupation on health and the Egyptian physician Imhotep documented injuries and treatment of workers engaged in heavy construction on the pyramids (Brandt-Rauf & Brandt-Rauf, 1987). However, such practices were more influenced by the need for an efficient workforce than any ethical or collective responsibility for employee wellbeing. The favourable health and longevity of some professions (priests) did not go unnoticed by ancient Egyptian scholars as the quote below

from the Greek scholar Isocrates attests by observing the leisure time, avoidance of the usual vices and drugs of nature (food) of Egyptian priests.

“Leisure through exemption from the hazards of fighting’ and ‘Thanks to such conditions of life, the priests discovered the aid of medicine for the body, using not dangerous drugs, but drugs of such a nature that they are as harmless as daily food, yet in their effects are so beneficial that all men agree the Egyptians are the healthiest and most long lived’

(Jouanna, 2012)

2.1.1 Occupational medicine

Bernardino Ramazzini, a 17th century Italian physician, is widely regarded as the founder of occupational medicine (Guiliano & Franco, 2001). Ramazzini furthered the teachings of Hippocrates by also considering the occupation of the patient (Sutherland, 1952) and is considered as among the first to acknowledge both the physical and psychological wellbeing of workers (Felton, 1997)(Felton, 1997). Ramazzini was also concerned with preventive work and health promotion and recognised the importance of physical activity and limiting prolonged sitting particularly for individuals employed in sedentary occupations (Giuliano, 2013). At a time when physicians were mostly the preserve of wealthy patients, Ramazzini was particularly noticeable for considering the socioeconomic impact on employee health (Franco, 1999).

The power of an individual employee to exact change is limited and as such the responsibility of protecting the wellbeing of the worker has historically rested with legislative and legal authority in the form of government and pressure from collective bargaining by union representation (Abrams, 2001). Many changes in working practices that concern employee health and wellbeing have resulted from fatal incidents that have evoked such public reaction as to require legislative change. A complete history of occupational health and wellbeing and health and safety legislation is beyond the scope of this thesis. However, it is important to note the pivotal historical moments that have shaped occupational health through accountability and how the relatively recent

emergence of various health and safety regulatory bodies have determined the legislative framework that underpins the current wellbeing of employees in the workplace.

2.1.2 Workplace injuries, health and disease

It is a sad historical truth that the most dramatic workplace change in support of employee wellbeing has come about as a result of catastrophic events typically involving a significant loss of life. However the strength of a particular event to enact change needs to be judged against the social context of the time. A review paper by Thackra (1860) sought to both investigate the conditions for workers and report the numbers of deaths and incidents according to occupation. It is perhaps an indication of the changing social fabric of the time that one of the motivations of the report was to educate the public in the difficulties experienced by employees, to stimulate discussion and change. A number of occupations were described according to the increased prevalence of ill-health conditions among the employees; millers, cotton-mill workers, dry-grinders, masons and pottery scourers all experienced frequent conditions as a result of lung irritation often developing into pulmonary disease (Thackra, 1860). Employees engaged in professions using toxic metals; brass smelters, plumbers, painters and file makers all reported often debilitating symptoms of either lead or mercury poisoning, that included loss of sensation and muscle spasm particularly at the site of contact in the case of lead (Thackra, 1860). Perhaps more well reported was the increased incidence of testicular cancer among chimney sweepers. The toxic accumulation of soot and subsequent absorption through the skin and inhalation was a frequent occupational hazard that was widely reported and squamous cell carcinoma (soot wart) was recognised by Percival Potts in 1775 as one of the first occupational diseases (Waldren, 1983). Interestingly it was later observed that German chimney sweepers did not suffer prevalence of the same disease, perhaps as a result of their tight-fitting clothing providing protection compared with the loose-fitted clothed or sometimes un-clothed UK employees (Waldren, 1983). Although not necessarily intended as such, this is perhaps an early example of the importance of personal protective clothing.

2.1.3 Asbestos and workplace disease

Asbestos is perhaps the most widely recognised industrial substance known to cause chronic disease, more specifically lung fibrosis (asbestosis) with a high risk of mesothelioma, 95% of which is as a direct result of asbestosis (Rudd, 2010). Industrial workers were exposed to asbestos through its use in cement and plastics and for lagging and fireproofing (Seaton, 2014). At the end of the 19th century, cases of asbestosis were rising rapidly amongst those exposed (Cooke, 1924) and 1930 saw the enactment of legislation to reduce employee exposure. It is amongst the building trade profession where exposure has been the highest and deaths are expected to continue to increase (Peto *et al*, 1999). However prohibition legislation has only been in place since the mid 1980s and the progression to lung cancer can be 20-30 years (Lazarus and Philip, 2011). It is only recently that the disease burden of asbestosis is being realised (Harding *et al*, 2009), with 1 in 150 men born between 1940-45 predicted to die of mesothelioma and although there has been some debate about the projected burden of the disease (Pelucchi *et al*, 2004), cases of mesothelioma are now expected to peak in the UK by 2015 (Hodgson *et al*, 2005).

2.1.5 Industrial villages

As the industrial age was established there was a substantial increase in requirement for housing and facilities to accommodate the large influx of workers migrating from rural to urban areas. A notable few industrialists recognised the importance of the built environment for promoting and ensuring a healthy and consequently productive workforce. Titus Salt, a woollen manufacturer, was the first to establish a purpose built village for his employees near to Bradford with added health-care, education and leisure facilities and a 14-acre park land (Ashworth, 1951). Other examples of built environments designed with employee health in mind included the Bourneville village by George Cadbury in Birmingham and a short time after, Port Sunlight Village by William Lever in the Wirral (Ashworth, 1951). These Victorian industrialists were amongst the first to observe that providing for and understanding the need of employee health and wellbeing improved productivity and helped the retention of a skilled workforce. However such strategies were the exception

rather than the norm and there was no legislative requirement to ensure the safety or wellbeing of employees.

2.1.6 Life expectancy and occupation

Annual Reports of the Registrar General in England were first published in 1840, using occupation as a means of comparing population health. By the mid 1900s it was already a statistical observation that employees engaged in certain professions experienced longer life expectancy compared to others. For example workers engaged in exercise driven professions such as gardening, thatching and labouring typically lived six years longer than coachmen and watchmen (Neison, 1845). This comparison was summarised and reported at the time (Table. 1). It was described as ‘unexpected’ that clerks on average reported a shorter life expectancy than plumbers, painters, glazers, bakers and miners (Neison, 1845). This was suggested to be because of the specific nature of the work of clerks, involving prolonged periods of sitting and inactivity. Although differences in lifestyle behaviours were suggested, no details were reported. However it was noted that a sedentary indoor profession was an improvement on a sedentary outdoor profession and that this was perhaps accounted for by the on average higher alcohol consumption of coachmen compared with shopkeepers (Thackra, 1845).

Table 2.2 Expected life duration at different decades of life for outdoor and indoor occupations of varying activity level during the 1900s. (Thackra, 1845).

Age	Expectation of life (years)			
	Indoor occupation		Outdoor occupation	
	Inactive	Active	Inactive	Active
20	41.88	42.01	37.80	43.42
30	35.12	34.50	30.14	36.58
40	27.91	27.80	23.04	29.13
50	20.50	21.18	17.28	21.97
60	14.04	15.14	11.02	15.56
70	8.65	10.44	4.56	9.33

As statistical techniques improved, it was understood that consistency of measurement and data collection was necessary for comparison and analysis of trends and subsequently an occupation classification system was developed. The classifications, included professional, intermediate, skilled non-manual, skilled manual, partly skilled and unskilled, and although modified and updated with social change, remain historically comparable (Marmot, 2017).

Although lifestyle behaviours were increasingly being recognised as important factors affecting the health and wellbeing of workers, it was not until the 20th century when employers appreciated the economic benefit of occupational health, that adoption of healthier workplace practices became more widespread (Black, Morris, Smith, & Townsend, 1980). It was also at this point that increasing interest was focusing on the health disparities between individuals engaged in varying job roles within the same workplace (Green, Dorling, & Mitchell, 2017). The seminal studies that informed this conversation are now recognised as the London Transport and Whitehall studies (Marmot et al., 1978; Morris & Crawford, 1958).

2.2 Occupation, lifestyle behaviours and health characteristics

2.2.1 London transport workers studies

The London Transport Studies were among the earliest studies examining the prevalence of chronic disease among employees engaged in job roles of differing physical activity requirements. The prevalence of coronary heart disease (CHD) was compared between driver and conductor employees of the London Transport Executive by examining the medical and absence records of approximately 31,000 men aged 35-64 years. The annual prevalence of CHD was reported at 2.7 per 1000, for drivers and 1.9 per 1000 for conductors, supporting the hypothesis that employees engaged in job roles requiring higher rates of physical activity had lower rates of CHD compared with more sedentary job roles (Morris *et al*, 1953). It was also noted that cardiac events among drivers were less likely to be fatal (30% versus 50% case fatality; drivers and conductors). The hypothesis was further tested and supported by comparing postmen involved in active delivering with postal depot based staff, telephonists and

clerks; reporting fewer cardiac events with increasing workplace activity (1.8/1000/year versus 2.0/1000/year versus 2.4/ 1000/year; active postmen, postal depot staff, telephonists/clerks). Further investigations found bus drivers typically had a larger waist circumference and body fat percentage at recruitment, suggesting that compared to conductors, drivers were in poorer physical health prior to employment (Morris, Heady & Raffle, 1956). This finding was important to consider in the context of population studies, such that individuals of particular physical characteristics migrated to specific occupations and were subject to retirement options for deteriorating health, which further contributed to a selection bias. Morris further investigated the relationship between cardiac health and physical activity of work by cross-referencing pathology reports of non-coronary deaths with employment history. Workers employed in occupations requiring light physical activity showed twice (13.4% versus 6.8% of cases) the myocardial fibrosis of those engaged in heavy occupational physical activity (Morris & Crawford, 1958). This study was among the first to report different cardiac adaptations among groups of workers engaged in occupations requiring varying amounts of physical activity.

2.2.2 The Whitehall studies

The London Transport Studies involved employees regarded as being of equal socioeconomic status and therefore less influenced by confounding due to social ranking. The Whitehall studies were among the first investigations to consider social determinants of health within the context of occupation and the socially ranked environment of the civil service. Whitehall II examined the health of 18,000 civil servants over a follow-up period of 10 years, finding higher prevalence of obesity, smoking and low physical activity level among men of a lower job grade, compared to higher grade. The differences in lifestyle behaviours between job grades were paired with higher CHD prevalence (3.6 times higher) among lower grade employees (Marmot, Rose, Shipley & Hamilton, 1978).

The London Transport Worker and Whitehall studies both investigated differences in health and lifestyle behaviours between employees engaged in various workplace activities. However the studies differed in their context such

that the socioeconomic environment of the civil service influenced the Whitehall studies, but the London Transport Worker studies used socioeconomic similarities between employees to determine if the workplace environment influenced health outcomes.

2.2.3 Occupation and geography

Although the philanthropic approach to employee wellbeing was likely motivated as much by a desire to improve workforce productivity, as it was a genuine concern for worker health, the geography of health became topic of interest in the 1900s with the identification of worker and regional health inequalities (Thackra, 1854). During the migration of workers from rural locations to the cities, it was identified that compared to employees in rural locations, the life expectancy of employees within industrial centers such as Liverpool was lower by in excess of 8 years at 30 years of age, and lower also compared with other UK cities (Neison, 1845). The higher concentration of unhealthy professions such as that of the Liverpool docker was a confounding factor when comparing life expectancy both with rural areas and with other industrial cities. However the differences in mortality could not solely be explained by occupation, suggesting the influence of both location and job role (Neison, 1845).

Results from the Global Burden of Disease Study (GBD) suggest that although living standards in general are higher compared to more than 100 years ago, there are still substantial differences in disease burden according to location (GBD, 2015). Health inequality between regions within the UK has been the focus of a number of government commissioned reports (Black *et al*, 1980, Acheson *et al*, 1998, Marmot *et al*, 2010) whose findings have been largely ignored despite criticism of government inaction (Court, 1981). However The Marmot report agreed with the observations of Neison from ~150 years previous; health inequalities are products of both geography and occupation (Marmot *et al*, 2010). For instance, compared with their managerial counterparts, unskilled employees in the North East and South West of England have more than three times and double the mortality rate respectively. Furthermore, health inequality is less noticeable when comparing managerial

positions between regions, but grows almost two-fold when comparing the North East with the South West for unskilled workers (Marmot *et al*, 2010). Although research studies are more advanced and ambitious in their scope and expertise, health inequality continues to manifest itself in socioeconomic (Isaacs and Schroeder, 2004) and geographical ways, presently without solution. The sociopolitical climate has exacerbated north/south health divides such that age-adjusted mortality in the north of England has increased by almost double that of the south of England and although overall deprivation has been declining recently within the UK, this trend recently has notable exceptions within northern areas of the UK (Kontopantelis et al., 2017). It is also noteworthy that in response to increasing mortality life expectancy forecasts were recalculated, suggesting that previously calculated life expectancy gains were no longer anticipated (Office for National Statistics, 2017). It is thought that increases in mortality and reductions in health care spending are related trends and sociopolitical products of austerity that are impacting more severely in areas of higher deprivation (Watkins et al., 2017).

The Health of the Nation Report (1992) was considered to be the first time the UK government had focused managerial attention on achieving health outcomes rather than achievement targets and the first time mental health had been given priority status (Department of Health, 1992). The white paper report was a response to the WHO ambitious 'health for all' report (WHO, 1981) and set terms of reference for the Workplace Task Force to cover five key areas; cardiovascular diseases, cancers, HIV, mental illness and accidents (Jenkins, 1994). The report although well intended, did not have the wider political support to implement change, however there is now increasing awareness that wider responsibility for promoting health and wellbeing and reducing health inequities, spans national borders and is reinforced by health and non-health sectors, private and public organisations, and communities. (Kickbusch and Gleicher, 2014). The challenge for government now is to enact policy that makes the healthy choice the easy choice, termed as smart governance for health, which recognises the challenge of shaping home and workplace determinants of health (Kickbusch & Gleicher, 2014).

2.2.4 Composition and context

Compositional and contextual resources have been used to encapsulate the geographical origins of health inequalities. Variations in lifestyle behaviours and social class are compositional, where physical, social and economic differences are described as contextual (Macintyre, Ellaway and Cummins, 2002). For example lifestyle behaviours are partly a function of individual characteristics (healthy people are more likely to continue to exercise) and local context (healthy people in an occupation with a fitness standard are more likely to be active than healthy people in a desk job) (Jen, Jones and Johnston, 2009). It is appropriate therefore to consider both context and compositional factors when determining the drivers of wellbeing in the workplace.

2.2.5 Population bias

When considering employee wellbeing it is important to understand the occupational characteristics that each population is exposed to, so that influences such as entry requirements, minimum job standards and retirement arrangements can be better understood for their potential confounding effects. The UK Fire and Rescue Service (FRS) is an employer with minimum physical entry standards (Siddall *et al* 2016; Stevenson *et al*, 2017), including medical screening, which until recently precluded applicants with diabetes, asthma, epilepsy, mental health conditions including depression and previous joint trauma such as knee injuries. However, replacement of the Fire Services Act (1947) by the Fire and Rescue Services Act (2004) removed any statutory requirement relating to appointment and promotions and required the UK FRS to comply with the Disability and Discrimination Act 1995 (amendment) 2003. This statutory change prohibited the automatic preclusion of applicants with specific medical conditions and required a more individual risk assessment approach (Gemmell, Kloss, Williams and Rayson, 2004).

The preclusion of hiring diabetic individuals has been reported as a confounder to studies investigating chronic disease risk among firefighting populations (Choi, 2000) and a mathematical model has been suggested for comparing disease risk between population studies (Choi, 2001). The healthy worker effect (McMichael, Spirtas and Kupper, 1974) describes a collection of

terms (healthy hired, healthy survivor), which acknowledge that the worker is generally healthy when employed and maintains health to remain in employment (Li and Sung, 1999).

The number of UK Fire and Rescue recruitments since 2003 is unknown and therefore the prevalence of medical conditions among new recruits are unclear. However it is reported that operational firefighter populations have reduced by approximately 20% since 2010 due to financial restraint (Home Office, 2016), thereby reducing the number entering employment. This should not have had a measurable effect on the prevalence of medical conditions within the UK FRS as the overall reduction in workforce numbers suggests that retirees have outnumbered new recruits.

2.3 The concept of health

The definition of health has been the focus of renewed discussion. The term health suggests the use of predefined physiological targets and as such enjoying good health is typically regarded in the presence of various physical characteristics. The term wellbeing would suggest the inclusion of a psychological component. The WHO World Health Report describes two main pathways where physical and psychological health are mutually influential (World Health Organisation, 2001). The first involves physiological systems including for instance neuroendocrine and immune functioning such that adverse moods stimulate deleterious changes within endocrine and immune systems leading to increased vulnerability to infection and disease (Black, 2002; Carney, Freedland, & Veith, 2005). The second is health behaviours such as diet, physical activity, sleep, alcohol, and smoking. The results of epidemiological research associate psychological disorders such as depression and anxiety with unhealthy lifestyle behaviours including poor diet, low physical activity, smoking, at-risk alcohol consumption (WHO, 2003). Indeed the relationship of some psychological disorders and health behaviour, such as physical activity, are considered to be bi-directional (Da Silva et al., 2012; Lopresti, Hood, & Drummond, 2013) and perhaps partly explain bi-directional relationships between depressive disorders

and chronic disease such as diabetes (De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006).

The dictionary definition of wellbeing is simply 'the state of feeling healthy and happy' (Stevenson, 2010). The WHO definition requires 'a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity', which was applauded for its ambition and scope at the time of its introduction in 1948. The WHO has since expanded its use of the term wellbeing, within its report on mental health, describing mental health as a state of wellbeing where individuals adapt to the normal stresses of life whilst contributing to their work and community environments (World Health Organisation, 2003).

However, the WHO has refrained from a redefinition of wellbeing and has since drawn two broad criticisms concerning the language used and a failure to adjust to the changing circumstances of population health (Huber et al., 2011). An alternative definition of wellbeing has been suggested to address these perceived limitations and to recognise the importance of adaptation and self-management for individual health (Huber et al., 2011). The concept of 'patient-centered' health has been investigated under six dimensions: bodily functions, mental functions and perception, spiritual/existential dimension, quality of life, social and societal participation, and daily functioning. The primary focus is not illness, but rather individual strength and research findings suggest that the broadest differences between patients and policymakers are in areas of health that involve spiritual, social and societal (Huber et al., 2016). A person-centered approach to health recognises that individual experience of chronic disease is not necessarily coupled with lower wellbeing but rather a shift in emphasis from the importance of bodily functions to that of spiritual, existential factors (Huber et al., 2016).

The shift to a more person-centered approach to health has a number of commonalities with the shift to a more individualised approach to health and wellbeing within the workplace setting. The Disability and Discrimination Act (1995) now requires that employers make reasonable workplace adjustments for employees that are challenged as a result of medical conditions. As discussed the emergency services, including the Fire Service, have adopted a 'person-

specific risk assessment' as part of a more individualised approach to recruitment (Gemmell, Kloss, Williams, & Rayson, 2004). This represents a considerable shift away from the mechanistic and militaristic recruitment and retention procedures that were previously adopted.

2.3.1 *Self rated health*

For understanding a personalised approach to health and wellbeing it is appropriate to consider self rated health. Self rated health is most typically assessed by using the single item question, 'How do you rate your health?' with answers assessed on a likert scale including excellent, good, fair, poor. It is suggested that self-rated health is the most widely used yet poorly understood health measure and raises questions of 'what do people know?' and 'how do people know what they know?' (Jylhä, 2009). Perceived health is one of the principal health indicators recommended for health monitoring of populations and was a key target within the health for all strategy of the WHO European Region. It is therefore surprising that more understanding of this global single item measure has not been put forward.

Self rated health is widely recognised as a good indicator of chronic disease risk (Waller, Janlert, Norberg, Lundqvist, & Forssen, 2015) and mortality (Idler & Benyamini, 1997; Jylhä, 2009). Although some of the association is explained by lifestyle factors, self rated health has been shown to be a strong predictor of incident and fatal CVD among healthy populations even after adjustment for, behavioural, socio-demographic and clinical risk factors (Reindl, Hummer, Eberstein, & Nam, 2004; van der Linde et al., 2013; Waller et al., 2015). However, it is unclear whether self rated health adds any predictive value in combined CVD algorithms with traditional risk factors (Waller et al., 2015). Yet there is some evidence of self rated health adding diagnostic value to health assessments among older populations (May, Lawlor, Brindle, Patel, & Ebrahim, 2006).

A conceptual model has been proposed by Jylhä (2009) to attempt to capture the determining factors involved in individual health status assessment. The model illustrates the interplay between context and evaluation such that the concept of health is historically and culturally variable and is influenced by ones

past experiences, current social networks and environment, and expectations (Jylhä, 2009). This may be important within the work environment such that the comprehensive, yet non-specific nature of self-rated health enables collection of data that could be missed by more objectively guided questions.

**'How is your health in general?
Is it excellent, very good, good, fair, or poor?'**

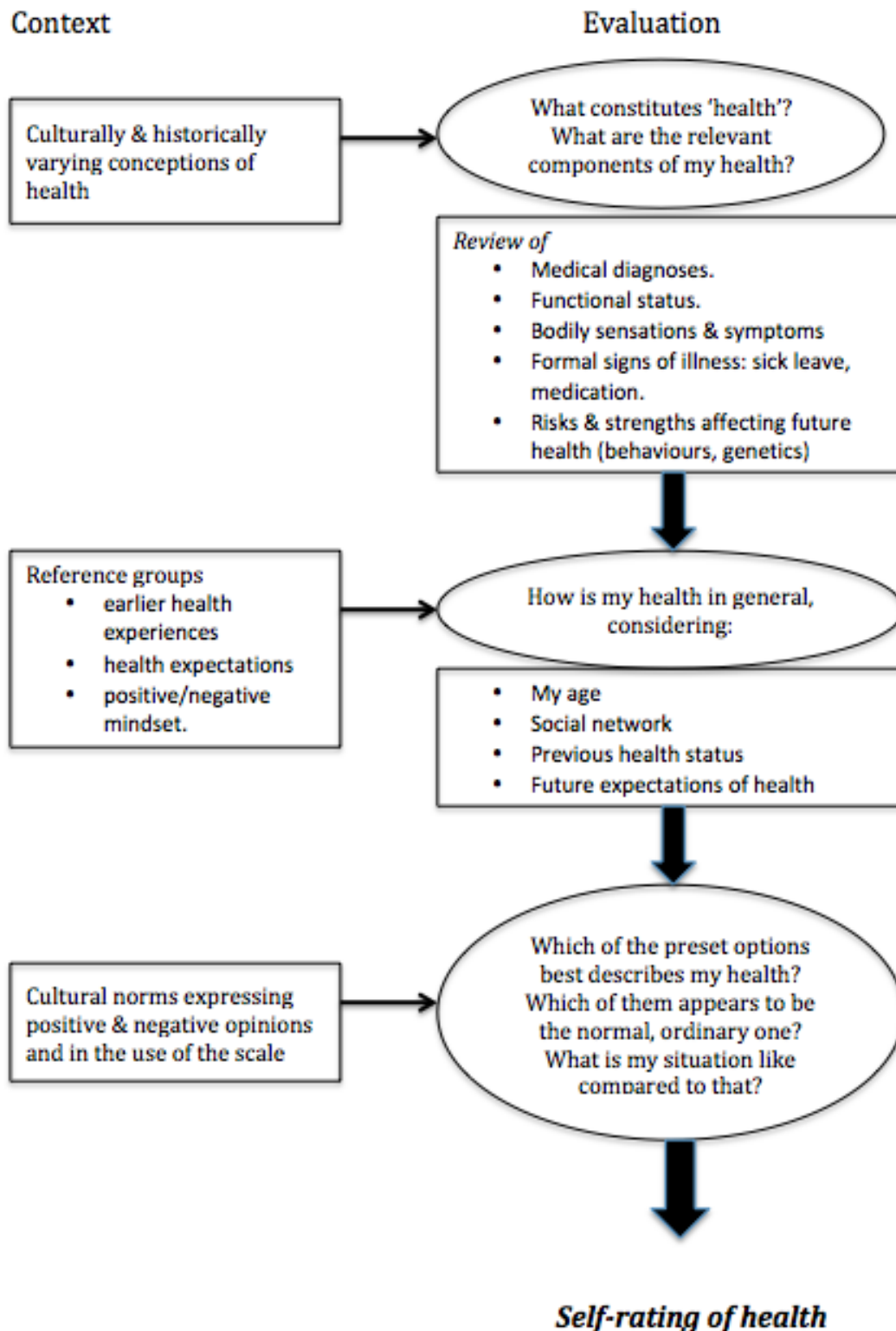


Figure 2. 3 Individual health evaluation (Jylhä, 2009)

2.4 Cardiovascular disease etiology

It is widely recognised that CVD is an inflammatory disease (Wellen & Hotamisligil, 2005). Indeed obesity promotes a state of chronic low-level inflammation (Wellen & Hotamisligil, 2005b) and provides the ideal environment for dyslipidemia and endothelial dysfunction (Steyers & Miller, 2014), which often coexist in CVD development. The etiology of CVD is thought to reflect in part the close relationship between metabolism and immunity (Ilhan & Kalkanli, 2015) and an evolutionary consequence that proves advantageous when energy resources are necessarily redistributed as part the inflammatory response (Hotamisligil, 2017). This close relationship is illustrated within adipose tissue and the liver, by the proximity of metabolic cells (adipocytes and hepatocytes) to immune cells (kupffer cells and macrophages) and is considered to be a factor in the development of metabolic dysfunction during extended periods of energy surplus (Hotamisligil, 2006). Immunometabolism is concerned with the interdependent metabolic pathways of immune cells, and their metabolic influence within adipose tissue and liver particularly and reflects an increasing awareness that evolutionary protective mechanisms developed during periods of energy deficit are not well suited to periods of energy surplus (Pearce & Pearce, 2013).

2.4.1 Inflammation

Inflammation is a normal physiological response to infection and tissue trauma (Medzhitov, 2008) that is characterised by a systemic cellular reaction and/or localised response at the site of tissue injury. The primary aim of inflammation is to restore normal function and host homeostasis (Cildir, Akincilar, & Tergaonkar, 2013). Stromal cells secrete proinflammatory cytokines that signal the presence of a bacterial agent and trigger the recruitment of circulatory neutrophils, platelets and adhesion molecules, as part of an immunoresponse process of repair and recovery. Cytokines, known as intracellular polypeptides, signal production of 'acute phase proteins' during the inflammatory state (Gabay & Kushner, 1999) and markers of inflammation, including C-reactive protein (CRP), are secreted by hepatocytes in response to

circulating proteins including interleukin-6 (IL-6) and tumor necrosis factor alpha (TNF α). A cascade of cellular processes responds to toll-like receptor cells and requires coordination of innate immune cells including macrophages, mast cells, monocytes and neutrophils in the 'acute phase response' (Baumann & Gauldie, 1994). Homeostasis is returned, following a normal inflammatory response, by various active anti-inflammatory processes that resolve the healing process and return serum biomarkers to trace concentrations. This process, until recently considered to be a passive response, is now understood to both actively protect tissues from further damage and promote the uptake and macrophage clearance of apoptotic cells (Serhan, Chiang, & Van Dyke, 2008).

2.4.2 Markers of inflammation

The inflammatory response has been extensively researched not least because of its role in response to tissue injury and infection, but more recently the concept of chronic low-grade inflammation (metainflammation) and its role in CVD progression (Hotamisligil, 2017). As discussed previously during a healthy immune response, serum concentrations of inflammatory markers return to mostly undetectable levels, however persistent biomarker concentrations at low levels are associated with development and progression of various chronic diseases (Danesh et al., 2004; Ridker, Hennekens, Buring, & Rifai, 2000).

2.4.3 Interleukin-6

Interleukin-6 (IL-6) is the predominant stimulator of the acute phase response (Heinrich, Castell, & Andus, 1990) and is involved in both pro- and anti-inflammatory processes that range from inflammation and infection to metabolic, restorative and neural pathways (Scheller, Chalaris, Schmidt-Arras, & Rose-John, 2011). The description of IL-6 as a myokine, secreted from muscle cells (Pedersen & Febbraio, 2008) and a pro-inflammatory cytokine secreted from adipose tissue (Coppack, 2001) illustrates the wide range of roles of IL-6 which supports its use as a measure of an individual's inflammatory state. Interleukin-6 is described as a 'higher order' cytokine to reflect its role in secretion and activity of a number of cytokines including C-reactive protein

(CRP). However the transient nature and diurnal fluctuations of IL-6 diminish its wider prognostic value (Meier-ewert et al., 2001).

2.4.4 Tumor Necrosis Factor

Tumor necrosis factor alpha (TNF α) is a pluripotent cytokine that is capable of inducing both its own synthesis and that of other cytokines, including IL-6 and was first described in animal studies investigating pro-inflammatory responses in the presence of chronic disease (Carswell et al., 1975). The physiological effects of TNF α have since been difficult to define due to the discovery of dual receptor pathways with contrasting intracellular effects (Nieto-Vazquez et al., 2008). Both pro-apoptotic and anti-apoptotic effects of TNF α have been demonstrated in human skeletal muscle, sarcopenia, liver and human adipocytes (Dirks & Leeuwenburgh, 2006). The site of secretion of TNF α influences its effects such that secretion from human adipose tissue has been shown to influence immune response as a regulator of inflammation and involvement in production of various other cytokines including IL-1 and IL-6 (Nieto-Vazquez et al., 2008). The metabolic effects of TNF α secretion from human adipose tissue is implicated in the development of insulin resistance through impairment of insulin-stimulated glucose disposal by inhibiting the insulin receptor tyrosine kinase in both muscle and adipose tissue (Hotamisligil, Budavari, Murray, & Spiegelman, 1994). In a study by Kern *et al*, insulin resistant subjects paired with more insulin sensitive subjects were matched for BMI and age and high levels of both TNF- α secretion and plasma IL-6 were both significantly associated with insulin resistance (Kern, Ranganathan, Li, Wood, & Ranganathan, 2013). Both IL-6 and TNF α were associated with obesity, however the strongest correlation was found between adipose secreted TNF α and plasma levels of IL-6 (Kern et al., 2013).

2.4.5 C-Reactive Protein

As discussed earlier IL-6 has down stream effects on the inflammatory cascade, including primary stimulation of CRP from hepatocytes within the liver (Danesh et al., 2004). Serum concentrations of CRP have been linked to increased risk of CVD (Ridker, 2003) and CRP has been proposed as a useful adjunct to

standard CVD risk stratification models (Ridker et al., 2000) not least owing to its longer half and lack of diurnal fluctuation (Meier-ewert et al., 2001). Serum concentrations of CRP are typically <10 mg/L, however during infection levels rise rapidly within the first 6 to 8 hours up to a peak of 350-400 mg/L after 48 hours. During this process CRP binds to phosphocholine on damaged cells as well as saccharides on pathogens, thereby signaling the immune cascade by stimulation of phagocytic cell activity as part of the opsonisation process (World Health Organization, 2014). During a normal inflammatory response CRP concentrations then return to almost undetectable levels and indeed are notably low among ultra endurance athlete populations (Tomaszewski et al., 2003). Established clinical cut-offs of CRP have been widely reported (Ridker, 2003, 2009) and are proposed as useful adjuncts to traditional CVD risk markers for identifying individuals at a low (<1mg.L⁻¹), moderate (1 to 3mg.L⁻¹) and high (>3mg.L⁻¹) risk of CVD (Pearson et al., 2003). However some reports question the usefulness of inflammatory markers in the presence of established risk factors (Danesh et al., 2004).

Emerging evidence supports the measurement of inflammation in conjunction with established healthy lifestyle behaviours, including physical activity. Lower inflammatory markers including IL-6, CRP and TNF α were associated with increasing physical activity amount and fitness level (LeCheminant, Tucker, & Russell, 2011) in both young (Accattato et al., 2017) and older populations (Colbert et al., 2004). Although exercise recommendations may require age adjustment, it is clear that physical activity in general has protective effects throughout the lifespan.

2.4.6 Endothelial dysfunction

During healthy homeostasis the endothelium maintains the vascular system in a neutral state in favour of dilatation rather than constriction (Widmer & Lerman, 2014). Nitric oxide promotes endothelium vasodilation and proliferation of vascular smooth muscle cells (Davignon & Ganz, 2004). Oxidative stress and inflammation are associated with endothelial dysfunction promoting an imbalance in nitric oxide production and consumption. These inflammatory conditions favour leukocyte and platelet activation and adhesion, and circulating

cytokines lead to increased vessel wall permeability to lipoproteins (Widmer & Lerman, 2014). Endothelium dysfunction is considered in the early stages of CVD (Davignon & Ganz, 2004) in the absence of any detectable disease (Steyers & Miller, 2014).

2.4.7 Lipoproteins

Lipoproteins have a single-layer phospholipid, cholesterol outer layer shell and enable the transportation of hydrophobic lipid molecules of various classifications, including chylomicrons, high-density lipoproteins (HDL-C), low-density lipoproteins (LDL-C), very-low density lipoproteins (VLDL-C) and intermediate-density lipoproteins (IDL-C) (Maxfield & Tabas, 2005). Apolipoproteins form part of the outer lipoprotein structure, involved in lipid cellular transport as cofactors for plasma enzymes and ligands for cell-surface receptors (Saito, Lund-Katz, & Phillips, 2004). Lipoproteins are implicated in CVD development through their presence in the intima of the arterial wall and the amount is associated with lipoprotein plasma concentration and size. Apolipoprotein B-containing lipoproteins in particular LDL-C are proposed as the main drivers of the atherogenic process (Tabas, Williams, & Borén, 2007) and is described as the response-to-retention model of atherogenesis (Williams & Tabas, 1995). This was a further step in understanding CVD as an inflammatory disease resulting in vascular damage (Ross, 1999), to the damaging consequences that retention of atherogenic lipoproteins cause the arterial wall (Tabas et al., 2007).

2.4.8 Cardiovascular disease risk in context

Although the underlying processes that determine CVD progression have been the focus of much research, the precise timing and factors that determine who develops CVD remains uncertain. Observational studies suggest that inflammatory processes, lipoprotein dysfunction and endothelial permeability contribute in various ways but their significance may depend on other factors. For instance in the presence of diabetes, permeability of the arterial wall appears to occur at lower LDL-C concentrations, and therefore it may be advantageous to

consider other factors when assessing individual risk using cholesterol sub fractions (Tabas et al., 2007).

The interpretation of CVD risk factors should be considered in context and with an understanding of environmental influences on behaviour. For instance, as discussed previously, the health impact of some CVD risk factors including overweight, smoking and cholesterol are multiplied in the presence of others such as low physical activity and prediagnosed chronic disease (Tabas et al., 2007; Van Gaal, Mertens, & De Block, 2006). Identification of employees with multiple CVD risk factors within the workplace setting has been identified to be an essential step for lifestyle intervention and healthy behaviour change (Yarborough et al., 2018). For some occupations, such as emergency response, this approach is an important determinant of employee safety and job performance (Smith, Barr, & Kales, 2013; Soteriades, Smith, Tsismenakis, Baur, & Kales, 2011).

2.5 Occupational epidemiology

Epidemiological research is concerned with investigating the causes and effects of health and disease among different predefined populations (Coggon, Rose & Barker, 2017). Although the scientific credibility of epidemiology is sometimes debated, epidemiologists are credited with extending average human life expectancy considerably during the 20th century. The workplace facilitates the study of predefined populations and presents an opportunity to compare health characteristics, lifestyle behaviours and disease prevalence between occupational groups (Porta, 2008). High blood pressure, smoking, high blood glucose, physical inactivity and overweight and obesity are the leading global risk factors for chronic disease (WHO, 2009). Indeed non-communicable diseases now account for most deaths globally and intervention strategies are required at both individual and population levels (Bauer *et al*, 2014).

Government and health care providers have been challenged to lessen the burden of non-communicable disease (Armstrong *et al*, 2014), which has been developed further to recognise the importance of wellbeing in the workplace (Bryson, Forth and Stokes, 2014). Occupation and conditions of work have been

cited as one of the social inequalities influencing health and wellbeing (Gray, 1982), which can be mitigated by employers with workplace practices that are sensitive to employee wellbeing. Higher employee wellbeing is associated with workplace performance benefits (Bryson, Forth and Stokes, 2014). Occupational epidemiology uses the workplace to investigate health and wellbeing within populations operating in an environment that is more predictable and structured than 'free-living conditions' (Checkoway, Pearce, & Crawford-Brown, 1989). As discussed health behaviours can vary between occupations. Smoking prevalence among the UK general population is 15.8% (ONS, 2017). However when smoking prevalence is reported by socioeconomic group, there are distinct differences according to occupation such that 24.6% of individuals employed in routine and manual jobs are smokers compared to 9.8% employed in managerial and professional roles (ONS, 2017).

2.5.1 Shift working and health

The effects of shift working on health have been the focus of considerable research. Comparisons between shift and non-shift workers report poorer health outcomes among shift workers (Knuttsen, Akerstedt, Jonsson, & Orth-Gomer, 1986) including increasing prevalence of CVD risk factors among shift workers (Esquirol et al., 2011; Haupt et al., 2008; Wyse et al., 2017) perhaps as a result of unhealthy lifestyle behaviours including lower physical activity amount and tendency to increase body mass (Pepłońska et al., 2014). Although it is uncertain whether poorer health outcomes among shift workers are a result of adverse lifestyle behaviours or shift working (Kivimäki et al., 2001) there is evidence of increased blood pressure among higher risk individuals exposed to shift work (McCubbin, Pilcher, & Moore, 2010). Indeed self reported sleep disturbance among individuals with a higher BMI (>25) has been reported as an independent predictor of heart failure (Ingelsson, Lind, Årnlöv, & Sundström, 2007). Differences in dietary intake according to BMI suggest that the tendency for weight gain among shift workers may be partly explained by variations in macronutrient intake (Dashti et al., 2015). Yet studies that have adjusted for differences in lifestyle behaviours have still found an increase in chronic disease

risk among shift workers compare to non shift workers (Haupt et al., 2008; Kawachi et al., 1995).

The work environment is complex and sleep characteristics require consideration of a number of sleep components including duration, quality, latency, disturbance, sleepiness, making interpretation and comparison of research studies challenging. A systematic review concluded that components of the work environment 'likely' impacted both positively and negatively on employee sleep disturbance, including psychosocial factors (social support; organisational justice; job control; high job demands; effort-reward imbalance) and shift work characteristics (exiting shift work; shift work generally) (Linton et al., 2015). Increasing risk of chronic disease among shift workers may be an artifact of changes to sleep as a consequence of shift patterns (Shanmugam, Wafi, Al-Taweel, & Büsselberg, 2013). Various plausible psychosocial, behavioural and physiological pathways exist between shift work and CVD. Psychosocial include managing work-life balance, working duration and inadequate recovery. Behavioural pathways are most likely smoking and weight gain and leading to physiological changes such as activation of the autonomic nervous system, and alterations to lipid and glucose metabolic pathways (Puttonen et al., 2010; Tucker, Marqui, Folkard, Ansiau, & Esquirol, 2012; Wong, Ostry, Demers, & Davies, 2012).

2.5.2 Sleep and health

As discussed, sleep is important for restoration and repair of many interrelated psychological and physiological systems (Strand et al., 2016), although the precise mechanisms by which this takes place remain under investigation. It is generally recommended that healthy individuals, between 26 and 64 years, require 7-9 hours and 65 years and older, 7-8 hours sleep duration per night (Hirshkowitz et al., 2015).

The sleep/wake cycle is a physiological 24-hour cyclic rhythm that is synchronised to the dark-light cycle. Rhythms that follow the 24-hour dark-light cycle are described as circadian (Germain & Kupfer, 2008). Disturbance of circadian rhythms is associated with metabolic changes similar to that of prediabetes (Buxton et al., 2012; Scheer, Hilton, Mantzoros, & McEwen, 2009)

and altered immune function. Poorer self-reported sleep quality has been reported to increase the risk of the metabolic syndrome (Jennings, Muldoon, & Hall, 2007) and its various component risk factors perhaps through deleterious effects on lipid and glucose metabolism. Various simulations have been completed exploring the effects of sleep loss on immune function. Increased plasma levels of both TNF α and IL-6 and their messengers suggest sensitivity of the cytokine system to total sleep deprivation (Shearer et al., 2001) and partial sleep loss (Irwin, Wang, Campomayor, Collado-Hidalgo, & Cole, 2006). Furthermore, after adjusting for age, socioeconomic status, BMI and smoking, longer sleep duration (>8 hours) has been shown to be associated with elevated levels of CRP, with evidence of a curvilinear relationship between inflammation and sleep duration (Jackowska, Kumari, & Steptoe, 2013). In support of this relationship, numerous studies implicate both short and long sleep duration in CVD development (Buxton & Marcelli, 2010; F. Cappuccio, Cooper, D'Elia, Strazzullo, & Miller, 2011; F. P. Cappuccio, D'Elia, Strazzullo, & Miller, 2010), in subjects without apparent sleep disorders (Gangwisch et al., 2006).

The health effects resulting from altered sleep behaviours during shift work provides a rationale for considering the contributions of sleep to overall health within the work environment experienced by emergency response. Considering the evidence proposed thus far, the expected mechanisms involved would be multifactorial and a consequence of the physiological and psychological stress exposure whilst operating various shift systems that challenge circadian rhythms and associated sleep/wake pathways.

2.6 Cardiovascular disease risk prediction and stratification

As discussed, it is now well established that behavioural risk factors in particular smoking, poor nutrition and physical inactivity are major drivers of the global CVD burden. The formative evidence base and understanding was developed from results of the Framingham Heart Study (1948), which randomly sampled two thirds of the adult population of Framingham, Massachusetts. Study findings from this seminal work showed that raised total cholesterol, elevated blood pressure and smoking were predictive of onset CVD (Kannel, Dawber,

Kagan, Revotskie, & Stokes, 1961) and introduced the use of 'risk factors' when describing CVD burden. Further analysis of follow-up work in the Framingham cohort identified additional risk factors including, physical inactivity, obesity and diabetes (Garcia, McNamara, Gordon, & Kannell, 1974) and the addition of lipid sub-fraction cut offs including LDL-C and HDL-C (Wilson et al., 1998).

The Framingham Study findings continue to influence CVD risk stratification (Mendis, 2010) and additional risk factors including inflammatory markers (Rogowski et al., 2005), psychosocial factors (Haynes, Feinleib, Levine, Scotch, & Kannel, 1978), job strain (Kivimäki et al., 2011) and sleep duration (Liu, Yuen, & Kang, 2014) have been suggested to add diagnostic value to the Framingham Risk Scoring. Furthermore, differences in risk factor burden have been shown to determine lifetime risks of cardiovascular disease that are consistent across race and age categories (Berry et al., 2012).

In the past decade a number of risk stratification models have been developed using the initial findings of the Framingham studies leading to population level interventions based on thresholds of risk. European guidelines define an absolute 10 year coronary event risk of >20% as high medical priority (Wood D et al., 1998), however more recent recommendations also recognise long-term risk such that the absence or presence of certain risk factors may lead to a low absolute 10 year risk but high predicted lifetime risk (JBS3 Board, 2014). These findings need to be balanced with the cost effectiveness of using CVD risk stratification tools for identification of high predicted CVD risk groups requiring targeted intervention (Crossan, Lord, Ryan, Nherera, & Marshall, 2017).

2.6.1 The Prospective Cardiovascular Munster Study

The Prospective Cardiovascular Munster Study (PROCAM) found that triglycerides, LDL-C and family history of premature coronary heart disease added diagnostic value to the original Framingham model. The study involved a cohort of 5000 men aged 35-65 years, followed every 2 years for a period of 10 years. The developed scoring system involved the prediction of a 'hard' coronary end point, described as a myocardial infarction or sudden coronary death during the 10 years of follow-up and assigned each score banding with an increasing

level of risk (Assmann, Cullen, & Schulte, 2002). A reported strength of the work included the use of a more complete lipid profile and the prediction of cardiac event mortality as a 'hard' end-point, perhaps reducing the likelihood of misdiagnosis and improving the use of lipid lowering interventions.

2.6.2 The Systematic Coronary Risk Evaluation Project

The systematic coronary risk evaluation project (SCORE) was developed in response to limitations of the Framingham studies that involved the over estimation of CVD risk among populations of lower risk compared to US populations, and difficulties in adjusting the model for use with European data sets (Conroy et al., 2003). The SCORE project approach represented a change from focusing on the causes of specific diseases towards the public health consequences of certain lifestyle behaviours. Risk estimates for fatal CVD event using SCORE are estimated separately for men and women using systolic blood pressure in smokers and non-smokers according to age group. Interestingly age is used as an indication of exposure time rather than a risk factor. Although limitations in the data collection prevented the direct inclusion of diabetes in the SCORE risk charts, the study authors suggested a rough estimate of CVD event in the presence of diabetes to be double in men and quadruple in women (Conroy et al., 2003). The SCORE prediction model has been recommended for use by the Third Joint European Task Force on CVD prevention (De Backer et al., 2003) and was appropriately validated using a Spanish population cohort (Sans, Fitzgerald, Royo, Conroy, & Graham, 2007).

2.6.3 The Scottish Heart Health Study

Standard CVD risk factors do not account for socially derived inequalities in health and disease. The Scottish Heart Health Study (Tunstall-Pedoe, Woodward, Tavendale, Brook, & McCluskey, 1997) randomly recruited from geographically diverse areas across Scotland and combined Scottish population cohorts from the WHO monitoring trends and determinants in cardiovascular disease project (MONICA) (Whoqol Group, 1995) to develop a CVD risk score (ASSIGN). The main difference with ASSIGN was the addition of social deprivation and family history to CVD risk prediction and although the

performance of ASSIGN (83%) and Framingham (79%) was similar for identifying high risk (20% cut-off) individuals, the use of ASSIGN may be justified in increasing health resource access to socially deprived groups (Woodward, Brindle, & Tunstall-Pedoe, 2007). Differences in CVD prevalence among more deprived areas, particularly in Scotland, support the inclusion of socioeconomic data within risk stratification modeling for specific populations (Fretz et al., 2016)(Woodward et al., 2007). Recent reporting of CVD trends within the UK has shown substantial decreases in age-standardised mortality from CVD but an increase in CVD prevalence, revealing the hidden burden of chronic disease (Bhatnagar, Wickramasinghe, Wilkins, & Townsend, 2016). These trends are also observed internationally, with decreases in cardiac event mortality but increasing CVD prevalence observed in the US (Rosamond, Folsom, Chambless, & Wang, 2001) and Finland (Salomaa et al., 1996).

2.6.4 The Q-Risk Score

The Q-Risk score was developed from the Q-research database that includes data from 529 UK GP practices and is subject to annual updates with changes in population characteristics including lifestyle behaviours (decreasing smokers, increasing obesity) and demographics (Hippisley-Cox et al., 2007). The Q-risk stratification model included age, total cholesterol/high density lipoprotein ratio, systolic blood pressure, body mass index, family history of premature CVD (first degree relative aged less than 60 years), smoking status, Townsend deprivation score, and history of blood pressure medication. The Q-Risk tool has performed well in independent validation (Hippisley-Cox, Coupland, & Brindle, 2014) and only marginally over estimates 10 year CVD risk (0.4%), compared to Framingham (35%) and ASSIGN (36%) (Hippisley-Cox et al., 2007). Furthermore the Q-risk tool has been subject to a number of comprehensive updates, such that Q-risk version 3 includes additional risk factors; chronic kidney disease (stages 4 and 5), migraine, systolic blood pressure variability, mental illness, systemic lupus, erythematosus, and medications; cortosteroids, atypical antipsychotics. The Q-Risk models perform similarly in population terms, however individuals reporting the additional

variables would be identified in the newer models and potentially benefit from risk reduction therapies (Hippisley-Cox, Coupland, & Brindle, 2017).

2.6.5 The Reynolds Risk Score

The Reynolds risk score was developed separately for men (Ridker, Paynter, Rifai, Gaziano, & Cook, 2008) and women (Buring & Cook, 2007) and includes both traditional and more novel risk factors in prediction of CVD events. Family history and CRP were considered to be independently associated with CVD events and added to age, systolic blood pressure, hemoglobin A_{1c} if diabetic, current smoking, total cholesterol and high density lipoprotein for the risk prediction model. Comparison with the Framingham risk tool, 40% to 50% of women (Buring & Cook, 2007) and 20% of men (Ridker et al., 2008) at an intermediate risk were reclassified more accurately into higher or lower categories.

In recognition of the need to customise risk prediction models to the observed population, a number of the aforementioned models were further adjusted with data from other populations. The SCORE equation was adjusted and validated for use among Spanish (Sans et al., 2007), Australian (L. Chen et al., 2009) and Belgium (De Bacquer & De Backer, 2010) populations and all reported improvements compared to Framingham and original SCORE models by adding national mortality statistics from their respective populations. It is widely agreed that CVD risk prediction tools are most valid and reliable when incorporating population specific CVD risk data.

2.6.6 Limitations of CVD risk prediction

Varying CVD risk estimates are possible depending on the risk calculator employed. In a comparison of 25 CVD risk calculators, risk factor agreement between pairs of calculators was 67%, but most concerning was that 41% of unique patients were placed within all 3 risk categories (low, medium, high) (Allan et al., 2013). It is recognised that CVD risk calculator have their limitations. First, most of the target population do not develop CVD during the 10 year risk prediction period, however the largest number of CVD cases will identify among this group simply because of the size of the population (Mureddu,

Brandimarte, Faggiano, Rigo, & Nixdorff, 2013). Second, risk prediction tools are sensitive to the reference population and may need further validation if applied to a different group (Sullivan & Wilson, 2001). Third, the time course of risk factor exposure may not be accurately reflected because of cross-sectional data collection (Abd, Blaha, Blumenthal, & Joshi, 2013). Fourth, CVD risk scores have been shown to be less reliable among certain sub-groups including the elderly (Yano et al., 2016).

2.6.7 Lifetime CVD risk prediction

Age and gender are influential determinants of absolute risk in all CVD risk prediction models (Abd et al., 2013) such that interventions set at thresholds of high risk ($\geq 20\%$) can miss opportunities for intervention at younger ages (JBS3 Board, 2014). The 'causal exposure model of vascular disease' describes age as the exposure time of the arterial wall to the deleterious effects of modifiable risk factors (Sniderman et al., 2012). However, the risk factor burden attributed to an individual at 50 years age is predictive of lifetime CVD risk and therefore supports a rationale for intervention strategies at earlier ages (Lloyd-Jones et al., 2006).

Long term lifestyle risk factor modification presents a challenge to health professionals and requires strategies to facilitate behaviour change without the proximity of CVD risk (Cobb, Brown, & Davis, 2006) and is often overlooked within primary prevention (Castaldo et al., 2005). Based on traditional CVD risk prediction modeling, the disease burden in individuals at a low 10-year risk of CVD development and high lifetime risk was compared with that of individuals classed as being at a low 10-year and low lifetime CVD risk. In support of using lifetime risk assessment, markers of subclinical atherosclerosis as indicated by a higher carotid intima-media thickness and coronary artery calcium score were both higher in the low 10 year/high lifetime risk group (J. Berry et al., 2009). This is particularly relevant for younger populations reporting lifestyle behaviours that expose them to a higher lifetime risk of CVD development in the presence of low 10 year CVD risk prediction.

2.6.8 Cardiovascular disease risk factor burden

The American College of Sports Medicine (ACSM) group individuals into low, moderate, or high risk based on the presence or absence of CVD risk factors, medical history describing signs and symptoms and/or known cardiovascular, renal, pulmonary or metabolic disease. The ACSM risk classification tool has the advantage of including lifestyle behaviours and health characteristics in the risk assessment process, whilst identifying individuals presenting with known disease as being at a high risk of an exercise related cardiac event (Pescatello, Arena, Riebe, & Thompson, 2013). This enables identification of individuals at greatest risk of cardiac event, whilst also recognising perhaps younger individuals presenting with unfavourable lifestyle behaviours that are typically missed by CVD risk algorithms. The ACSM tool describes CVD risk as low (<2 risk factors), moderate (≥ 2 risk factors), or high risk (pre-disclosed signs/symptoms of pulmonary, cardiovascular and/or metabolic disease). Risk factors include age (men ≥ 45 yr; women ≥ 55 yr), cigarette smoking (current smoker or cessation ≤ 6 months), sedentary lifestyle (≤ 1000 Mets \cdot week $^{-1}$), obesity (BMI ≥ 30 kg \cdot m $^{-2}$ or WC > 102cm, men; > 88cm, women), hypertension (pre-disclosed on health and lifestyle survey), dyslipidemia (pre-disclosed on health and lifestyle survey), prediabetes (assumed if; age ≥ 45 yr and BMI ≥ 25 kg \cdot m $^{-2}$ or age <45yr and BMI ≥ 25 kg \cdot m $^{-2}$) (Pescatello et al., 2013). Incorporating lifestyle behaviours into CVD risk classification may have relevance for fire and rescue personnel engaged in physically and psychologically challenging emergency response activities. Occupational health professionals may better identify individuals for lifestyle behaviour intervention at an earlier stage.

2.7 Risk factors associated with cardiovascular disease

The impact of risk factors associated with CVD has shifted with ageing populations (Lim et al., 2012), with a substantial proportion of the global disease burden attributable to specific risk factors including high blood pressure, smoking, high blood glucose, physical inactivity (WHO, 2009) and poor nutrition (Murray et al., 2013; WHO, 2003). The risk factors associated with CVD exert

their influence over an extended period, such that age represents the time of exposure. Large epidemiological population based studies over a long period have enabled risk estimation based on observed mortality and are also useful for comparison of groups based on risk factor prevalence.

The Multiple Risk Factor Intervention Trial (MRFIT) and Chicago Heart Association Detection Project in Industry (CHA) were combined and individuals identified as low risk (serum cholesterol < 5.17; systolic/diastolic blood pressure of $\leq 120/80$ mmHg; non smoking; no prior history of CVD; no ECG abnormalities) were compared with individuals with one or more risk factors according to age group. Findings reported lower CVD and CHD death rates (77% to 92%) consistently among the low risk cohorts irrespective of age group (Stamler et al., 1999). Furthermore the findings may have underestimated the advantage of the low risk group as details regarding nutrition and physical activity level were not measured (Stamler et al., 1999). Even though risk factors associated with CVD development are widely known and have been reported over a number of years, the prevalence of non-communicable disease of which CVD represents the greatest burden, is still increasing and is now the focus of global targets (Armstrong et al., 2014).

2.7.1 Physical activity and health

Physical activity affects every organ in the human body and is fundamentally important for physiological (Paffenbarger, Blair, & Lee, 2001) and psychological wellbeing (Cotman, Berchtold, & Christie, 2007). Furthermore individuals maintaining regular physical activity patterns experience on average a lower risk of CVD development (Andersen et al., 2014) and all cause mortality. The UK Chief Medical Officer recommends that healthy adults should aim to engage in physical activity of moderate intensity for thirty minutes on at least five days per week (Bull et al., 2010). Current physical activity recommendations also consider limiting the amount of sedentary time, understood to be behaviours where sitting or lying is the typical posture and energy expenditure is very low (Bull et al., 2010). These guidelines are in response to the sedentary nature of modern societies. Indeed technological advances, including increasing

mechanisation and automation have removed increasing amounts of physical activity from daily routines.

The workplace offers both challenges and opportunities for physical activity intervention. Modern workplace environments are typically designed for long periods of seated office work. A number of large observational studies have reported associations between sedentary behaviours and CVD particularly among inactive individuals (Åsvold, Midthjell, Krokstad, Rangul, & Bauman, 2017; Petersen, Bauman, & Tolstrup, 2016). Current workplace strategies for reducing sedentary behaviours include increasing daily standing and walking time, including regular breaks to avoid prolonged sitting and combined with education on improved nutrition, alcohol reduction, smoking cessation and stress reduction (Buckley et al., 2015). The curvilinear dose-response relationship between physical activity and health (Department of Health, 2011) identifies the least active to be the main risk reduction beneficiaries when increasing physical activity amount. Observational studies report associations between higher workplace physical activity, wellbeing, work productivity and reduced sitting time (Puig-Ribera et al., 2015).

2.7.2 Nutrition and health

Nutritional intake is a key factor in determining health and wellbeing. At an autonomic level the human body influences food intake by exerting executive control on various appetite regulation systems to promote energy balance. Energy balance is achieved when energy intake equals energy expenditure. However the equation is perhaps over simplistic in the context of the modern environment. Indeed the modern environment that populations live and work in is considered to be one of the main drivers for food choices that are higher in calories rather than nutritional value (Hall, 2017) and easy access to energy-dense affordable processed food is widely considered to be the one of the main drivers of obesity. The WHO classifies nutrition as a major modifiable determinant of chronic disease and describes the nutritional transformation that has taken place in most modern economies as a shift from largely plant-based diets to high-fat, energy-dense diets which are increasingly animal-based (WHO, 2003).

2.8 Excess body mass and health

2.8.1 Classification

The Quetelet index, as first described by Belgian mathematician Adolphe Quetelet in 1832, recognised the relationship of body mass increases after birth and puberty as height (m) divided by weight (Kg) squared (Eknoyan, 2008). The WHO established BMI categories (underweight: <18 ; normal weight: $\geq 18 < 25$; overweight: $\geq 25 < 30$; obese: $\geq 30 < 35$) (WHO, 1995) are widely adopted (NICE, 2014) and the risk of chronic disease increases with each category. However BMI is not a direct measure of adiposity and has received criticism for being a crude estimate of excess body weight (De Lorenzo *et al*, 2013). It is estimated that half of all adults with excess body fat are misclassified as non-obese, suggesting that although most BMI obesity diagnoses are accurate (high specificity), many are misdiagnosed as normal weight (low sensitivity) (Okorodudu *et al*, 2010). However the discriminatory power of BMI should be judged by the prevalence of chronic disease among obese individuals and it is reported that in excess of two thirds of BMI related deaths are as a result of cardiovascular disease (CVD) (GBD, 2017). Evidence also suggests that when considering mortality from CVD, obesity is most appropriately defined as an excess of body mass relative to height, rather than excess adiposity (Ortega *et al*, 2016).

Excess abdominal adiposity or visceral fat, increases the risk of metabolic dysfunction including reduced insulin sensitivity, decreased glucose tolerance and abnormal lipid profile and is associated with onset of type 2 diabetes and developing CVD (WHO, 2008). Waist circumference (WC), waist-hip ratio (WHR) and waist-height ratio (WHtR) are commonly used proxy measures of visceral adiposity. Standard measurement protocol for WC is the circumference at the approximate midpoint between the bottom of the ribcage and the top of the iliac crest and hip circumference should be taken around the widest portion of the buttocks (WHO, 2008). Abdominal obesity is defined as WC ($>1.02\text{m}$ males, $>0.88\text{m}$ females), WHtR ($\geq 0.90\text{m}$ males, ≥ 0.85 females). Identification of abdominal obesity using WHtR has been demonstrated to have good reliability when compared with gold standard computed tomography visceral adiposity

assessment in both men and women (Roriz *et al*, 2014). Recent research supports the use of WHtR as a simple and sensitive diagnostic tool for early identification of individuals at increasing (WHtR ≥ 0.5) risk of chronic disease (Swainson *et al*, 2017) independent of gender and ethnicity (Browning, Hsieh and Ashwell, 2010).

2.8.2 A Global problem

Excess body mass is a global problem that has reached epidemic proportions. Indeed between 1995 and 2015 the global deaths from high BMI increased by 25%, with CVD as the leading cause (The GBD 2015 Obesity Collaborators, 2017). Population studies report inverse associations between healthy lifestyle behaviours (Mediterranean diet, moderate alcohol, daily physical activity, no smoking) and both general and abdominal obesity (Bulló *et al*, 2011) suggesting that excess body mass is a proxy measure for modifiable lifestyle behaviours. The deleterious effects of some modifiable lifestyle behaviours, such as smoking, have been shown to increase in the presence of obesity (Messner & Bernhard, 2014). Furthermore excess body mass both during adulthood (Hu *et al*, 2004), adolescents and childhood (Berenson *et al*, 1998) is associated with increasing risk of diabetes and CVD.

2.8.3 Physiological effects

Adipose tissue is both an endocrine and paracrine organ (Van Gaal *et al*, 2006) that is actively involved in the production and perfusion of a variety of peptide and non-peptide compounds.

The pathophysiological effects of excess body mass are multifactorial and increase the likelihood of metabolic abnormalities including insulin resistance, endothelial dysfunction, and lipoprotein abnormalities (Poirier *et al*, 2006). Although persistent inflammatory processes are widely reported in the presence of excess body mass, it is suggested that obesity is a product of inflammatory disease (Das, 2001) characterized by increased secretion of inflammatory cytokines and production of macrophages within adipose tissue (Khodabandehloo, Gorgani-Firuzjaee, Panahi, & Meshkani, 2016).

2.8.4 Insulin resistance and metabolic dysfunction

In the presence of excess body mass, the risk of insulin resistance and diabetes shows a dose response relationship such that insulin sensitivity is impaired by excess adiposity (Colditz et al., 1990). Adipose tissue behaviour depends on a number of factors that include location, size and distribution within the body (Heymsfield & Wadden, 2017). For instance upper-body obesity is associated with excessive ectopic fatty acid deposition, adversely affecting local cell function including insulin-signaling processes (Evans, Murray, & Kissebah, 1984; Tchkonina et al., 2013) and insulin resistance is associated with excess intra-abdominal fat (Kaur, 2014). Although not fully understood, it is suggested that elevated lipolytic activity from abdominal adipocytes increases intraportal free fatty acid levels, inhibiting insulin clearance and promoting insulin resistance (Kahn & Flier, 2000).

Adipocytes are highly insulin-responsive cell types, by which adipocyte triglyceride storage is promoted through a number of processes including lipogenesis (B. Kahn & Flier, 2000). The glucose lowering action of insulin is the product of both hepatic glucose production suppression and enhanced uptake of glucose into mostly muscle and some adipose tissue stores (Kahn & Flier, 2000). Evidence of decreased insulin sensitivity in the presence of alterations in the fatty-acid content of muscles suggests a role in modulating insulin levels (Borkman et al., 1993) and identifies skeletal muscle as a principal site of insulin-stimulated glucose clearance (Koves et al., 2008). In obese individuals mitochondrial oxidative phosphorylation activity within skeletal muscle can be compromised, resulting in incomplete fatty acid oxidation and risk of skeletal muscle insulin resistance (Evans et al., 1984). In skeletal muscle, the ability to both switch between utilisation of carbohydrate or fatty acids for energy production is often impaired among obese individuals (Koves et al., 2008). In a laboratory-based study, muscle samples were taken from individuals with a broad range of BMI (~ 20 to 32 kg m^{-2}) and tested in vitro for metabolic flexibility. Dynamic changes to fat oxidation in muscle cells were related to characteristics of the donor that included aerobic capacity, body fat and fasted insulin level (Ukropcova et al., 2005). Insulin resistance among obese individuals may also involve lower rates of fatty acid oxidation under fasted conditions (Kelley,

Goodpaster, Wing, & Simoneau, 1999). Lipid accumulation within the skeletal muscle of obese individuals is a perhaps therefore more a result of decreased fatty acid oxidation than increased fatty acid uptake.

2.8.5 Visceral fat and health

Visceral fat is understood to exert independent increases in CVD risk, which has been demonstrated in a number of large population based studies (Bulló et al., 2011; Carmienke et al., 2013). The precise mechanisms for this are unclear, however abdominal fat is associated with higher circulating markers of inflammation independent of insulin resistance, perhaps through the actions of pro-inflammatory cytokines including IL-6 and TNF α released from adipose tissue (Festa et al., 2001). Excess adipose tissue accumulation around and within vital organs including the kidneys, the liver, the pancreas and the heart is associated with metabolic dysfunction (Heymsfield & Wadden, 2017). Indeed excess adiposity can lead to an expansion of liposomes, small cytoplasmic organelles found near the mitochondria of various cell types, and may result in lipotoxicity causing cell dysfunction and apoptosis (Tchkonia et al., 2013).

2.8.6 Non-alcoholic fatty liver disease

Ectopic fat accumulation in the liver is an emerging health problem, symptomatic of excess body mass. Indeed liver transplants due to non alcoholic fatty liver disease (NALD) were unknown 10 years ago, now comprise 25% of liver transplants among individuals that are typically obese, hypertensive, with a higher prevalence of diabetes mellitus and metabolic syndrome (Quillin et al., 2014). Fatty liver has traditionally been associated with alcohol intake (White, Altmann, & Nanchahal, 2002), however the global prevalence of NALD has seen similar trend increases to that of obesity (Younossi et al., 2016) and 80% of type II diabetic individuals are considered to have NAFLD (Targher, Lonardo, & Byrne, 2017). Although a high incidence of NAFLD has been reported in obese individuals (Ludwig, Viggiano, McGill, & Oh, 1980), the mechanisms involved in disease progression through non-alcoholic steatohepatitis (NASH), fibrosis and cirrhosis, are unclear. It is known that mitochondrial structural defects and insulin resistance both appear to be involved in the transition to NASH (Sanyal et

al., 2001). Indeed fatty liver is thought to explain why obesity is not always observed in insulin resistant individuals (Kelley, McKolanis, Hegazi, Kuller, & Kalhan, 2003) and markers of liver fat including serum concentrations of alanine aminotransferase have been shown to predict CVD independent of excess body mass (Yki-Jarvinen & Westerbacka, 2005). The mechanisms linking NAFLD to the development of CVD and diabetes are not fully understood, although the clustering of metabolic abnormalities often present are well reported and often collectively referred to as the metabolic syndrome.

2.8.7 Metabolic syndrome

Insulin resistance is not a disease but a description of a metabolic state that links a number of physiological processes with increasing risk of CVD and diabetes (Reaven, 2005). As such, the scientist that initially termed the phrase metabolic syndrome rather described it as a diagnostic tool to facilitate intervention and CVD risk reduction (Reaven, 2006). The metabolic syndrome is used to describe a clustering of risk factors for CVD and type 2 diabetes mellitus that typically include hypertension, dyslipidemia, central obesity, elevated fasting glucose (Kaur, 2014). A metabolic syndrome diagnosis is not dissimilar to that of CVD risk stratification in its use for risk assessment, with initial treatment being lifestyle modification followed by targeted drugs if necessary. Although there is a determination to have an agreed set of standards, diagnostic criteria for the metabolic syndrome vary between organisations including the WHO (K. Alberti & Zimmet, 1998) The Adult Treatment Panel III (ATP III, 2001) and The International Diabetes Federation (IDF) (K. G. M. M. Alberti et al., 2009) (Table 2). It is well recognised that increasing risk of CVD development is associated with a clustering of risk factors that underpin the diagnostic criteria for the metabolic syndrome, however concern surrounds whether the empirical evidence supports its use over and above the treatment of individual risk factors (R. Kahn, Buse, Ferrannini, & Stern, 2005).

Table 2. 2 Metabolic syndrome classification criteria

Metabolic syndrome classification criteria		
WHO ¹	IDF ²	ATP III ³
Glucose intolerance or diabetes mellitus and/or insulin resistance with two or more of:	Any three of the following:	Any three of the following:
<ul style="list-style-type: none"> • Blood pressure $\geq 160/90$ mmHg. • Triglycerides (≥ 1.7 mmol·L⁻¹) and/or HDL (< 0.9 mmol·L⁻¹ male; < 1.0 mmol·L⁻¹ female). • Central obesity (waist to hip ratio > 0.9 males; > 0.85 females) and/or BMI > 30 kg·m⁻² • Microalbuminuria (urinary albumin excretion rate \geq ug min⁻¹ or albumin:creatinine ratio ≥ 20 mg·g⁻¹). 	Systolic blood pressure ≥ 130 or diastolic ≥ 85 mmHg. <ul style="list-style-type: none"> • Triglycerides ≥ 1.7 mmol·L⁻¹ • HDL (< 1.0 mmol·L⁻¹ males; < 1.3 mmol/L, females). • Elevated waist* • Fasting plasma glucose ≥ 5.6 mmol·L⁻¹ 	<ul style="list-style-type: none"> • Blood pressure $\geq 130/85$ mmHg • Triglycerides ≥ 1.7 mmol·L⁻¹ • HDL (1.036 mmol/L male; 1.295 mmol·L⁻¹ female) • Waist (> 102 cm male; > 88 cm female). • Fasting glucose ≥ 6.1 mmol·L⁻¹

¹WHO; World Health Organisation: ²IDF; International Diabetes Federation: ³ATP III; Adult Treatment Panel III.

*European waist circumference thresholds; ≥ 102 cm male, ≥ 88 cm women. Non-European; ≥ 94 cm male, ≥ 80 cm female.

2.8.8 Societal costs of excess body mass

The chronic disease risk of excess bodyweight is widely reported (Ezzati & Riboli, 2013; WHO, 2009; Wormser et al., 2011) and is associated with a slowing or even decrease in life expectancy gains (Olshansky *et al*, 2005). Compared to normal weight individuals, life expectancy on average in severely obese individuals is 5 to 20 years lower (Redden, Wang, Westfall, & Allison, 2003) and the increasing prevalence of excess bodyweight is impacting on life expectancy forecasting. Indeed the Office for National Statistics (ONS) revised

their 2014 life expectancy data as a result of changing population patterns (Office for National Statistics, 2017b). Excess bodyweight is associated with unsustainable associated health care costs (Royal College of Physicians, 2013) that may present a greater burden on resources than tobacco and alcohol (Strum, 2002). Tackling the disease burden of excess bodyweight is recognised as a public health priority (Department of Health, 1995), which requires an approach that acknowledges both socio-behavioural and environmental influences (Prentice, 2006).

Recent studies have furthered understanding of excess bodyweight as a complex societal problem (Butland *et al*, 2007) with multiple biological, behavioural and genetic components (Ghosh and Bouchard, 2017) that requires a long-term strategy to reverse a trend that currently has no short or medium term solutions (Butland *et al*, 2007). In spite of the global trend towards excess bodyweight (Abarca-Gomez *et al*, 2017; Finucane *et al*, 2011) and its health consequences (Murray *et al*, 2017), no successful national intervention to tackle overweight has been reported (Ng *et al*, 2014). Indeed many investigators regard the lack of government action in addressing the socioeconomic drivers of obesity, particularly from early childhood, as a symptom of the difficulty tackling health inequality in general (Hemmingsson, 2018).

2.9 UK Fire and Rescue Service

The UK Fire and Rescue Service (FRS) is comprised of 46 English FRSs, the Scottish FRS, North, South and Mid & West Wales FRSs and Northern Ireland FRS, with each operating under different administrative and legislative requirements. Although there are differences between administrations, including operating procedures and equipment, UK FRS job roles can broadly be described as operational, emergency control, administrative support (Figure 1). Historically, operational roles are mostly populated by males (~95%), emergency control roles by females (~95%) and administrative support a combination of both male and female (60:40), in favour of males (Department for Communities and Local Government, 2013; The Scottish Government, 2013;

Welsh Government, 2012). The UK FRS has focused considerable resources to promote the operational role as gender neutral, however this has resulted in only marginal increases of females employed in operational roles (Home Office, 2016).

2.9.1 Fire and rescue role; operational

Operational employees are frontline firefighters (FF) that typically ride a fire appliance as part of a twenty-four hour shift based rota-system. There are a number of different shift systems in operation within the UK FRS, with the most prevalent shift system described as the two-two-four shift-system. This is an eight-day rotating shift pattern that involves four groups rotating on a two-day, two-night, four-rota day system. Whilst on duty, operational employees maintain a constant operational readiness for emergency response, whilst engaged in a daily work routine. The daily work routine varies between FRS with some commonalities that include maintenance of practical-based skills and prevention activities aimed at reducing emergency incidents. Operational firefighters are not typically desk based, but it is difficult to define a typical daily workplace physical activity amount or daily sedentary behaviour. Emergency response activities are widely reported as requiring a mean oxygen uptake of $42\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$ (Gledhill & Jamnik, 1992; Stevenson, Siddall, Turner, & Bilzon, 2017) which is typically classed as vigorous intensity activity (Pescatello et al., 2013). Previous studies have described firefighters as being engaged in prolonged periods of inactivity, interspersed with short periods of near maximal effort (Gemmell et al., 2004). It is recognised that FF require regular physical training to maintain a minimum cardiorespiratory standard of $42\text{ml}\cdot\text{kg}\cdot\text{min}^{-1}$ (Stevenson et al., 2017). Best practice guidelines recommend annual fitness testing, underpinned by a consultation with an occupational physician every three years (Stevenson et al., 2017).

2.9.2 Fire and rescue role; emergency control

Emergency control (EC) employees are engaged in emergency mobilising roles that are typically desk based. Their role requires a twenty-four hour shift based rota-system. The predominant EC shift pattern echoes the two-two-four

operational firefighter shift pattern, involving four groups operating a rotational two-day, two-night, four rota-day system. There is no occupational fitness standard requirement and EC employees are not typically supported by access to occupational health professionals, although arrangements vary between FRS regions.

2.9.3 Fire and rescue role; administrative support

Administrative support roles (AS) within the UK FRS are typically office based. Although some administrative support roles may be populated by operational firefighters that have been redeployed, most employees are recruited to fulfill specific support roles and do not have any operational experience. Administrative support employees typically work a flexible duty time system that involves giving an agreed number of hours within a defined daily window that is usually 07.00hrs to 18.00hrs, with essential hours between 10.00hrs to 14.00hrs. There is no role specific occupational fitness standard and AS are not typically supported by access to occupational health professionals, although again such provision does vary between FRS regions.

3.0 Occupational stressors of emergency response

Emergency response workers are exposed to a wide range of physical and physiological stressors during periods of shift work. Firefighters are exposed to infrequent periods of intense physiological (Gledhill & Jamnik, 1992) and psychological strain (Eglin, 2007). Soteriades *et al*, 2011 describes these occupational stressors as either chronic (sedentary periods, smoke, noise, shift-work, unhealthy diet, psychosocial) or acute (unpredictable physical exertion, smoke, noise, heat/dehydration, alarm response, firefighting activities) and contributing to the cardiovascular strain of firefighting (Figure 2.4) (Soteriades, Smith, et al., 2011).

A similar workplace model characterises the cardiovascular strain of firefighting considers individual characteristics. In the occupational model proposed by Smith *et al*, 2013, the magnitude of occupational stressors are

determined through individual characteristics including health status and fitness profile suggesting that an individuals fitness may buffer against the cardiovascular strain of firefighting (Figure 2.3) (Smith et al., 2013).

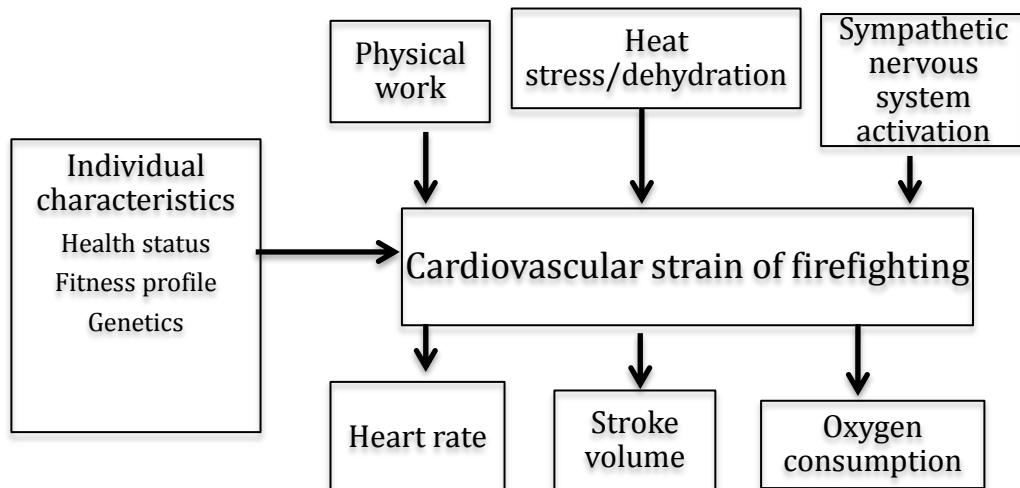


Figure 2. 3 Cardiovascular strain of firefighting (Soteriades *et al*, 2011).

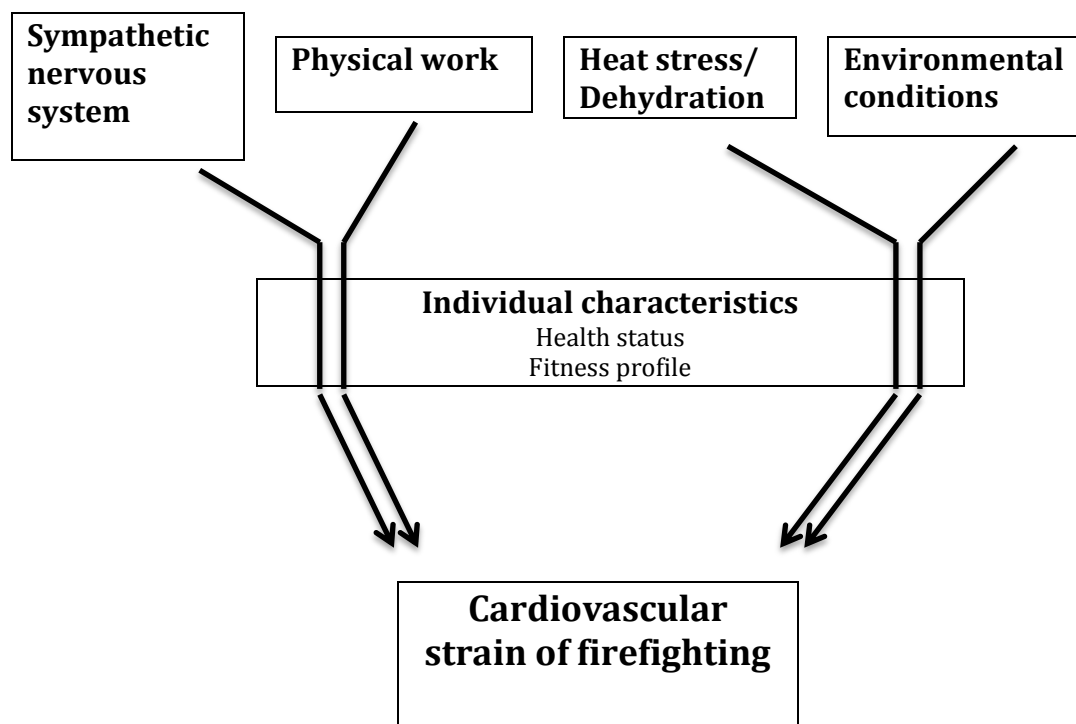


Figure 2.3 Factors affecting the cardiovascular strain associated with firefighting (Smith *et al*, 2012).

Although the overall cardiorespiratory benefit of regular physical activity is unquestionable (Andersen et al., 2014), there is a transient increase of cardiac event risk during periods of heavy physical exertion (Mittleman et al., 1993). Furthermore the risk of cardiac event is increased in individuals who are habitually sedentary and greatly reduced among individuals engaging in regular vigorous activity (Albert et al., 2000) and stressful events as experienced during emergency response are associated with increased risk of cardiac event (Stefanos et al., 2003; Varvarigou, Farioli, Korre, Dahabreh, & Kales, 2014). Therefore identification of employees that may present as being at an increased risk of disease is a fundamental aim of occupational health practitioners. A risk based approach is important not only for allocation of limited resources, but most importantly it encourages targeting individuals that may be exposing themselves and other employees to unacceptable levels of job specific task failure. In certain professions, such as emergency response, the consequences of task failure may pose a risk to life.

4.0 Firefighter populations

4.0.1 Cardiovascular disease risk factors

Best practice recommendations are for firefighters to complete annual health assessments (Siddall et al., 2016). Although periodic health assessments are best practice, they are not mandatory within the UK FRS and the availability of assessment data for analysis and comparison is inconsistent and uncoordinated making a health assessment of UK firefighter populations challenging. Most research investigating health characteristics in firefighter populations has been published among US firefighters. Body mass trends are consistent with overweight and obesity trends among the US general populations (Mokdad et al., 1999). Also in agreement with general population trends, obesity within the Fire and Rescue Service is associated with increasing absence from work. Self-reported poor health days among a group of US firefighters increased substantially in the presence of extreme obesity, compared to normal weight (19 additional poor health days annually), with similar

increases using waist circumference or body fat percentage and adjusting for age, ethnicity, alcohol, smoking, marital status and any comorbidities (A. L. Brown et al., 2014).

A group (806) of US firefighters were monitored for approximately 6 years, including weight, blood pressure, smoking, fasting glucose and lipid profile (Glueck et al., 1996). The study used a coronary risk scoring system based on Framingham data and follow up examinations were based on age (40 years threshold) and presence of any major CHD risk factor. The study group was case matched according to BMI, blood pressure and cholesterol, from the National Health and Nutrition Survey, to reduce any confounding from a healthy worker effect. During the study follow-up, twenty-two firefighters developed coronary artery disease of which most notable almost 50% were smokers and hypertensive at baseline. This study perhaps encouraged a period of adjustment in studying firefighter populations such that the introduction of improved self-contained breathing apparatus furthered the recognition that any increased cardiac risk was perhaps more apparent due to mostly modifiable risk factors (Glueck et al., 1996).

Obesity and CVD risk were investigated in a group of 116 US male firefighters. CVD risk classification (Pescatello et al., 2013) did not differ between obese and non-obese groups, perhaps owing to the small sample size, yet three quarters of firefighters were identified as being at either moderate or high CVD risk. Furthermore, a high prevalence of obesity (51.7%) and overweight (43.1%) were reported among this population and obesity was associated with higher circulating CRP and differences in vascular function (Smith et al., 2012). Systolic blood pressure only was higher among obese, compared to non-obese, which may have been an artifact of most non-obese firefighters being classified as overweight and may have also confounded measurable differences in cholesterol profiles (Smith et al., 2012).

Lifestyle behaviours and CVD risk factors were evaluated in a cohort of 779 male Quebec firefighters by online questionnaire. Using ACSM CVD risk stratification (Pescatello et al., 2013), 33.1% and 43.6% of firefighters were identified as moderate and high risk of CVD respectively. Cardiorespiratory fitness decreased markedly with each increase in BMI category, coupled with

increasing prevalence of modifiable CVD risk factors, including lower physical activity levels and higher inactivity (Gendron, Lajoie, Laurencelle, & Trudeau, 2018).

Obesity rates among a group of US firefighters were monitored over a five year follow-up period and prevalence increased from 35% to 40% (Soteriades et al., 2005). Among the increase was a shift from obesity I ($30 \leq \text{BMI} \leq 35$) to obesity II ($35 \leq \text{BMI} \leq 40$) and extreme obesity III ($\text{BMI} \geq 40$). Hypertension prevalence was higher among obese compared to non-obese. Complete lipid profiles were measured follow up only and although total cholesterol did not differ between obese and non-obese, the prevalence of low HDL-C ($\leq 2.3 \text{ mmol/L}$) was higher among the obese group (Soteriades et al., 2005). The trend of increasing overweight and high prevalence of obesity have been repeated in a number of US firefighter populations with prevalence similar (Fahs et al., 2009) or worse (Byczek, Walton, Conrad, Reichelt, & Samo, 2004; Poston et al., 2011) than US general populations. Furthermore in a cohort of emergency response recruits (mean age ~ 26 years) over two thirds were overweight ($\text{BMI} \geq 25 \text{ kg/m}^2$) and one third were classed as obese ($\text{BMI} \geq 30 \text{ kg/m}^2$) (Tsismenakis et al., 2009). The trend of increasing obesity prevalence among firefighters is associated with an increasing risk of job disability, with upwards of 60% increase in risk of disability compared to firefighters of normal weight (Soteriades et al., 2008).

Increasing levels of overweight and obesity have also been reported among UK firefighter populations with similar transitions of overweight to obese categories, even though overall numbers of overweight were less compared to US firefighter populations (Munir, Clemes, Houdmont, & Randall, 2012).

Hypertension among FRS personnel and has been cited as independently associated with cardiac event (Kales, Soteriades, Christoudias, & Christiani, 2003) and cardiac event mortality (Geibe et al., 2008). Investigations have attempted to elicit further insight of on-duty cardiac stressors experienced by firefighters. A cohort of 112 firefighters completed an exercise stress test and on-duty 24-hour electrocardiographic recording (Al-Zaiti & Carey, 2015). Although a third of study participants were hypertensive, only a fifth had received a diagnosis and/or medication. Exercise stress testing results diagnosed myocardial ischaemia and reported concerns requiring further investigation in

almost 12% and 19% of cases respectively. Findings from 24-hour ECG monitoring identified more than half of participants with at least one high-risk ECG risk factor. A very high prevalence of overweight (49.1%) and obesity (33.9%), and smoking (13%) would likely have contributed to the exercise stress testing and ECG observations (Al-Zaiti & Carey, 2015). Investigations and comparison in more healthy firefighter cohorts may provide further insights.

4.1 Firefighter interventions

Firefighter workplace intervention programs are not widely reported, perhaps reflecting the challenges involved when implementing changes in a dynamic and unpredictable workplace setting. However some intervention programs have been implemented with two broad aims; to facilitate and encourage healthy lifestyle behaviours and to improve psychological wellbeing through behaviour change. These studies allow some interpretation of the relationship between workplace wellness programs and employee wellbeing and chronic disease risk.

4.1.1 Healthy lifestyle behaviour interventions

Health characteristics and fitness levels among firefighter recruits typically require both the passing of a minimum fitness standard on entry and passing initial training before continuing to maintain role-specific cardiorespiratory fitness and strength levels. Improvements to body composition and cardiorespiratory fitness have been demonstrated among US firefighter recruits. An exercise intervention among US firefighter recruits resulted in favourable changes to body composition by increasing lean tissue and decreasing fat mass and a substantial increase in mean aerobic capacity (~28%), demonstrating the effectiveness of early health and lifestyle intervention programs (Roberts, O'Dea, Boyce, & Mannix, 2002). Similar improvements have been observed among incumbent firefighters. During a 16-week on-station exercise intervention, cardiorespiratory fitness increased compared to controls and also buffered the stress response to a simulated rescue scenario (Throne, Bartholomew, Craig, & Farrar, 2000).

Weight gain is a career risk among firefighter populations and requires consideration if emergency response tasks are to be continued without increased risk of musculoskeletal injury or undue cardiac strain. Weight surveillance has been used effectively to reduce weight gain in a firefighter population. In a cohort of US firefighters body composition and health behaviours were measured at baseline and 9-month follow-up. Individuals that changed diet, physical activity or both following initial feedback, lost significantly more body mass than individuals that reported no behaviour change and significant predictors of change were higher baseline BMI, taking cholesterol medication. As reported the findings support the notion that those that perceive their risk to be elevated with respect weight and cholesterol were more motivated to make changes (Poston, Jitnarin, Haddock, Jahnke, & Tuley, 2012). The positive impact of healthcare professionals on firefighter weight perception has been shown elsewhere (Brown et al., 2015), however the long term impact on lifestyle behaviours including physical activity is less clear.

4.1.2 The use of technology in health interventions

Wider improvements in cardiorespiratory fitness and body composition profiles among US firefighters have been unsuccessful as indicated by a mean BMI of 28 kgm⁻² (Storer et al., 2014) and increasing obesity prevalence (Soteriades et al., 2005). This has prompted collaboration between a number of FRS stakeholder organisations and academic experts to investigate the use of technology to identifying and mitigating CVD risk factors within firefighter populations.

The Surveying and Assessing Firefighter Fitness and Electrocardiogram (SAFFE) study is an on-going National Institute of Health (NIH) supported investigation to identify and quantify CVD risk factors in firefighter populations. A cohort of the SAFFE study was recruited to measure effectiveness of a 12-week low glycemic index diet and intensive exercise intervention program. Anthropometric measurements, blood pressure and lipid profiles were reported prior to the intervention, at 6-weeks, 12-weeks and a 6-months follow-up. The 12-week intervention successfully reduced body mass, BMI, waist circumference, body fat percentage and blood pressure. Although the findings were

encouraging, further research is necessary to validate the results due to the small sample size (Al-Zaiti & Carey, 2015).

The Promoting Healthy Lifestyles: Alternative Models' Effects study (PHLAME) was part of government funded US Fire Service and academic stakeholder group to promote healthy eating, regular physical activity and normal body weight among firefighters. The study compared a team-centered peer-led group, an individual group utilising motivational interviewing and a testing, results only control group (Elliot et al., 2007). At one year follow-up compared to the control group, both the team-centered and individual motivational interview groups had improved healthy dietary behaviour, lower weight gain and higher overall wellbeing (Elliot et al., 2007). Although the PHLAME study did not impart significant changes to cardiorespiratory fitness or physical activity behaviour, comparisons of Fire Services with and without PHLAME participation demonstrated reductions in reported injury claims (Kuehl et al., 2013). Further analysis of the PHLAME study tested mediator effects through action and conceptual theories. For instance prior knowledge of exercise benefits was high in both team and control groups making any further intervention based improvement perhaps less likely (action theory failure). However increases in knowledge of fruit and vegetable benefits and food monitoring were associated with increased fruit consumption and also coworker exercise expertise related to exercise behaviour change (conceptual theory success) (Ranby et al., 2011). The PHLAME study attempts to explain the complex workplace environment that firefighters make behavioural choices in highlights the need for further research in this area.

The Physiological Health Assessment System for Emergency Responders (PHASER) is a software platform designed to monitor a number of physiological variables (resting blood pressure, fasting blood glucose, serum cholesterol, aerobic capacity, BMI) to assess individuals and provide support and confidential health assessment feedback (Batalin et al., 2013). A web portal gives the user confidential access to physiological data, providing bespoke recommendations to improve health and wellbeing and producing a health and wellness report based on the most relevant CVD risk factor variables. The software is user led and can be enabled to give dynamic feedback including notification of goal

accomplishment and any risk factors that require intervention. The PHASER system is perhaps the first user led monitoring system that empowers individual firefighters to monitor their physiological data whilst providing discreet and tailored interventions where appropriate. Testing of the third generation PHASER system is ongoing (Batalin et al., 2013).

The 'Fuel to Fight' study is an ongoing longitudinal study investigating CVD risk factors and measured effects of wellbeing and fitness on health and safety in US firefighters. Initial findings reported comparisons between Fire Services with and without a comprehensive wellness program. Wellness program provision was measured against the Wellness-Fitness Initiative (WFI); annual health assessments, a designated fitness coordinator, peer fitness trainers, provision for on-duty fitness training. Fire Services satisfying WFI requirements were matched to randomly selected controls according to a number of potentially confounding variables and then three fire stations were randomly selected from within each identified wellness (n=522) and control (n=480) groups. Compared to no wellness provision, individuals within Fire Services providing a wellness program had improved body composition across all measures and 10% less obesity, higher reported physical activity and a lower prevalence of hypertension and psychological disorders. In agreement with other studies within firefighter populations (Haddock et al., 2012) binge and heavy drinking were prevalent among both groups, although the control group were more likely to be heavy drinkers and smoke. Furthermore, the wellness program firefighters were more likely to report greater optimism, job satisfaction and sense of achievement (Poston, Haddock, Jahnke, Jitnarin, & Day, 2013). The study is novel in its attempts to reduce potential confounding due to selection bias and comprehensive in reporting both health characteristics and wellbeing relative to the presence of a workplace wellness program.

4.1.3 Psychological wellbeing interventions

The 'Working for A healthier Tomorrow' UK government review highlighted the importance of psychological wellbeing within the workplace and the need to identify factors that negatively impact wellbeing and implement appropriate interventions (Black, 2009). As discussed previously in this review,

firefighters are exposed to psychological stressors as a routine part of their role, which can have a negative impact on wellbeing (Wesemann et al., 2018). Physical activity is reported to be an effective moderator of the stress response and may have antidepressant effects that offer some resilience from psychosocial stressors (Hamer, 2012). It is surprising therefore that the psychological effects of exercise interventions have not received more widespread attention among firefighter populations. The effect of an exercise intervention on stress reactivity was investigated in a group of US firefighters. Participants completed a sixteen-week rowing exercise intervention, whilst completing an emergency response simulation at baseline and post intervention. As expected the exercise intervention improved physical fitness, but interestingly compared to the control group, the exercise intervention group had lower cardiovascular stress reactivity (mean arterial pressure) to the simulated fire scenario. The exercise intervention group also reported less anxiety and negative affect prior to the simulation. The findings suggest that both physical fitness and the psychological stress response in firefighters can be improved (Throne et al., 2000).

CHAPTER 3

General methods

General Methods

3.1 Study location

A health and lifestyle survey (Appendix A) was compiled and hosted on an online survey platform (SurveyMonkey). An initial pilot survey (Jan 2012) was conducted giving access to a single FRS to test the online platform and identify any errors prior to a national launch. The survey was made accessible via the UK FRS internal intranet systems and links were also shared on social media platforms for a period of six months (Feb-July 2012).

3.2 Study design

The target population for the study included all employees of the UK FRS. An online health and lifestyle survey was considered the most appropriate method so that access to the survey could be facilitated through an online portal via established UK FRS communication networks. There are approximately 60,000 UK FRS employees engaged in one of three job roles (Department for Communities and Local Government, 2013; Home Office, 2016; The Scottish Government, 2013; Welsh Government, 2012). Job roles within the UK FRS are broadly identified as operational firefighter (FF: 82%), emergency control (EC: 3%), and administrative support (AS: 15%) and vary considerably by gender where FF are mostly male (95%), EC mostly female (80%) and AS male: female (60:40).

3.3 Participants

The health and lifestyle survey was intended to be available to all UK FRS employees irrespective of job role or shift pattern. The FF role includes emergency response activity as defined by responding to, and attending, emergency incidents, associated maintenance of a minimum physical fitness standard and are shift working; EC role includes emergency call handling, are typically office-based and shift working; and AS role is administrative, office-based and typically non-shift working.

Internal communication networks were utilised to increase confidence that the survey rationale and associated information was disseminated to each UK FRS. Participants were recruited as volunteers through internal FRS communications. An initial communication was distributed as a Chief Fire Officer Association (CFOA) circular in February 2012 (Appendix C), followed by an update and further circular in April 2012 (Appendix D). The progress update included confidential feedback for each FRS to learn participant numbers for their organisation and decide if further internal communication was necessary to increase representation. Paper copies were made available where online access was not possible. The principal investigator completed any data entry of surveys completed in paper format.

3.4 Ethical requirements

The study received ethical approval from the University of Bath Research Ethics Approval Committee for Health (REACH, University of Bath). All participants gave informed consent after reading a written description of the study on the front page of the survey. Ticking the informed consent box on the first page allowed access to the survey.

3.5 Health and Lifestyle Survey

3.5.1 Population surveys

The World Health Organisation 'Health for All Strategy' challenged governments to prioritise population health such that all citizens could lead a socially and economically productive life (WHO, 1981). Regular monitoring and evaluation of population health were key objectives in this process largely through population surveys. Population surveys describe data collection from a sufficiently large number of respondents so that systematic analysis allows representation of the target population in particular for self perceptions of health and lifestyle behaviours (WHO, 1996).

The UK FRS health and lifestyle survey was constructed to gather information on the health characteristics, lifestyle behaviours and perceived psychological wellbeing of employees of the UK FRS. The survey comprised of four sections; general information, lifestyle behaviours, perceived psychological wellbeing, sleep behaviours. Where appropriate answers were given using drop down boxes and options for measurements in either metric or imperial. The survey was comprised of four sections; general information, lifestyle, psychological wellbeing, sleep. All questionnaires used in the UK FRS health and lifestyle survey and associated scoring protocol is included in Appendix A and Appendix B.

3.5.2 Section one: general information

Participants were asked for personal details including age, sex, ethnic origin, postcode, employment, salary bracket, shift system (Table 1), FRS role, height, weight, waist, single item self-rated health and any prediagnosed medical conditions. Age, postcode, employment length, employer, FRS role, height, weight and waist circumference were completed using drop down boxes. All questions required answers, except salary bracket, which was considered to be a potential source of participant concern. Sex and ethnicity questions were structured in agreement with the UK Census survey protocols (ONS, 2011b, 2011a).

Table 3.2 Predominant shift patterns in the UK Fire and Rescue Service.

Shift pattern	Description
1-3 (24hrs, 3 rota days)	Rotating shift of 4 groups; night shifts
2-2-4 (2 days;2 nights, 4 rota days)	Rotating shift of 4 groups; night shifts
Self rostering*	1 group self-rostered; night shifts.
Day crewing*	2 groups; 3 days/nights.
Day crewing plus	1 group self-rostered; night shifts.
Retained	1 group, home based; night shifts
Flexi-duty	Supervisory officers; night shifts
9 day fortnight	Office based
10 day fortnight	Office based
Part-time	Office based

* For administrative staff this shift would not typically include night shifts

Unit postcodes are the base units of postal geography and include outward and inward sections. By including the first letters of the outward code, sufficient geographical data was gained whilst ensuring participant anonymity (ONS, 2011a). Height, weight and waist circumference were required answers and options were made available in imperial and metric using drop down boxes.

Self-rated health was assessed with a single-item global health question where participants were asked to rate their health as either 'excellent', 'good', 'fair', 'poor' (Benyamini, 2017). Self-rated health is widely reported to predict both chronic disease onset and mortality through the individual's subjective assessment of their own health status (Idler & Benyamini, 1997; Reindl et al., 2004; Waller et al., 2015). The assessment is based on sometimes known diagnoses and health indicators but often information that is perceived through social and cultural experiences may influence self-rated health (Jylhä, 2009).

3.5.3 Section two: lifestyle

Section two of the survey included questions on physical activity, nutrition, alcohol and smoking.

3.5.4 Physical activity

Physical activity surveillance necessitates the use of valid, reliable and sensitive measures of physical activity behaviours (Shephard & Aoyagi, 2012). At the population level this is particularly important for investigating dose-response relationships between health and exercise volume, duration and intensity (Dowd et al., 2018). Self-report physical activity survey protocols facilitate the largest number of participants, are relatively inexpensive to administer, and are the most commonly used measurement tool (Sallis & Saelens, 2000; Shephard & Aoyagi, 2012).

Firefighters are required to pass a minimum fitness standard at recruitment and maintain a role-specific minimum fitness standard during employment. Therefore for the firefighter role, compared with other FRS roles, it was anticipated that a greater volume of physical activity and greater proportion of vigorous physical activity would be reported. The present study therefore required a self-report physical activity questionnaire that collected data on both

work and leisure time physical activity behaviours, whilst differentiating between various exercise intensities such that all physical activity was included.

The IPAQ was designed to facilitate cross-national monitoring of physical activity and inactivity (Bauman, Bull, et al., 2009) and is available in both long (31 items) and short (9 items) forms. For feasibility the short form is recommended for population-based studies (Craig et al., 2003). Although the IPAQ short-form has reported over-estimation when compared against activity monitors (Bauman, Ainsworth, et al., 2009), both the vigorous physical activity and sitting components have reported acceptable reliability and criterion validity (Kurtze, Rangul, & Hustvedt, 2008). A comprehensive meta-analysis previously tested the convergent validity of the International Physical Activity Questionnaire (IPAQ), such that each exercise intensity domain was compared against objective measurements taken from activity monitors. Positive effect size results of small to medium range were reported, including the greatest effect size for vigorous physical activity (Kim, Park, & Kang, 2013). The IPAQ short-form was chosen for reliability and validity across differing population groups, whilst reporting on both exercise intensity and volume.

The IPAQ short-form includes seven items assessing time spent being physically active in the last seven days, during work and at home. Weekly physical activity pattern is categorised as vigorous, moderate and walking and the volume of activity is calculated by weighting each physical activity category by its energy requirements as defined in METs to produce a MET-minutes total (Craig et al., 2003).

MET-minutes/week calculations

Walking = 3.3 * walking * walking days.

Moderate = 4.0 * moderate-intensity activity minutes * moderate days.

Vigorous = 8.0 * vigorous-intensity activity minutes * vigorous-intensity days.

Total physical activity = sum of Walking + Moderate + Vigorous scores.

Adapted from (Craig et al., 2003)

3.5.5 Nutrition

It is well established that nutrition is a key modifiable determinant of health and wellbeing and dietary factors are understood to be fundamental for prevention (Armstrong et al., 2014; Boeing et al., 2012; Mattei et al., 2017; WHO, 2003) and management (Dyson et al., 2011) of chronic disease. However despite this clear association and modifiable labeling, effective lifestyle interventions targeting dietary behaviour at a population level are challenging. Evolutionary biologists suggest that strong evolutionary processes drive individuals to make dietary choices based on sub-conscious, cost-benefit analysis that motivate food selection by calorie density rather than nutritional quality (Finch, 2010; Mann, 2000; Ulijaszek, 2002). A more sociological perspective suggests the environment and culture that individuals increasingly habituate makes selection of processed food the easiest choice (Mehta & Chang, 2008). Indeed, environmental factors are sensitive to the study population, such that the school environment is associated with nutritional choice in children (Fraser, Clarke, Cade, & Edwards, 2012) and work environment for working adults (Burgoine, Forouhi, Griffin, Wareham, & Monsivais, 2014).

In the present study a comprehensive assessment of nutrient intake and comparison with dietary reference values was beyond the scope of the project given the intentional number of measures in the survey and participant burden. Rather dietary intake assessment required the use of a brief questionnaire protocol with demonstrable reliability and designed to report on a 'typical' or 'average' time period. The primary focus for dietary assessment in the present study was a broad comparison of food intake between FRS occupational roles. Dietary assessment questionnaires with demonstrable validity and reliability have not been previously reported among firefighter populations. However, a modified version of the nutrition section of the Rapid Eating and Activity Assessment of Patients (REAP) has shown acceptable reliability among a military population (Robinson et al., 2010).

The REAP was designed as a brief food habit assessment tool that could be self-administered. REAP is a 27-item questionnaire that assesses intake of whole grains, total fat, saturated fat, cholesterol, fruit, vegetable, dairy and meat.

The REAP questionnaire has reported acceptable test-retest reliability with the healthy eating index (HEI) score (Gans et al., 2003, 2006).

3.5.6 Alcohol

Moderate alcohol consumption is associated with a lower risk of CVD (Mukamal et al., 2003), however alcohol consumption described as 'hazardous and harmful' is associated with increasing CVD risk (Kauhanen, Kaplan, Goldberg, & Salonen, 1997). Research suggests that alcohol consumption equivalent to approximately 1 drink/night over 5 nights for females and 1-2 drinks/night over 5 nights for males is associated with a lower risk of CVD (Wood et al., 2018). In Mediterranean countries this relationship is perhaps modified such that higher amounts of alcohol are tolerated before associations with CVD are detected (Corrao, Rubbiati, Bagnardi, Zambon, & Poikolainen, 2000) perhaps reflecting the presence of environmental confounders.

Studies among US firefighter populations have reported alcohol to be widely consumed, with a high prevalence of hazardous drinking behaviours (Carey, Al-Zaiti, Dean, Sessanna, & Finnell, 2011; Haddock et al., 2012). It is important therefore to understand alcohol consumption behaviours within firefighter populations. The alcohol use disorder identification test (AUDIT) was designed assess problematic drinking patterns, rather than dependence and is the result of a multinational WHO collaborative project (Allen, Litten, Fertig, & Babor, 1997). The original AUDIT comprised of 10-items, however a shortened version (AUDIT-C) is available without compromising reliability or validity (Bradley et al., 1998) and internal consistency of the AUDIT-C is acceptable (0.69-0.91) (Bergman & Källmén, 2002; Gómez, Conde, Santana, & Jorrín, 2005; Tsai, Tsai, Chen, & Liu, 2005). The AUDIT-C is a 3-item questionnaire with answers weighted 0 to 4 depending on frequency of consumption, with scores ranging from 0-12 and a suggested cut off of ≥ 5 for problematic drinking.

3.5.7 Smoking

Smoking is widely recognised as one of the most important modifiable risk factors for the prevention of CVD (Messner & Bernhard, 2014). Although smoking prevalence has decreased substantially since the 1960's (Office of

National Statistics, 2014) the burden of chronic disease attributable to smoking is considerable (Thun et al., 2013). Furthermore, smokers on average lose one decade of life expectancy compared to non-smokers (Jha et al., 2013).

Smoking prevalence among firefighter populations is typically lower than that of the general population or comparable military populations (Jitnarin, Haddock, Poston, & Jahnke, 2013), however smoking prevalence has been reported to be higher among firefighters reporting hazardous drinking (C. K. Haddock et al., 2012).

The Cigarette Dependence Scale (CDS-5) is a shortened version (5-item) of the full (12-item) scale used to assess smoking status and history (Jean-Francois Etter, Le Houezec, & Perneger, 2003). The questionnaire has demonstrated test-retest reliability ($r=0.83$) and internal consistency (Cronbach's $\alpha > 0.84$) (Jean-François Etter, 2005). The questionnaire involves 5-items and reports on smoking status and smoking dependency (Jean-Francois Etter et al., 2003).

3.5.8 Section three: psychological wellbeing

Section three included questions on psychological distress (depression, anxiety, stress, positive affect, negative affect) and positive psychological wellbeing (satisfaction with life).

3.5.9 Depression, anxiety and stress

Depression, anxiety and stress are generally considered to be separate negative emotional states, but have clinical overlap such that stress often precipitates periods of depression and anxiety and stressful life events can be followed by periods of arousal (Lovibond & Lovibond, 1995).

The depression, anxiety and stress schedule (DASS) is a self-administered questionnaire designed to capture the extent of each of these negative emotional states; depression scale measures feelings of low mood, motivation, and self-esteem; anxiety scale measures perceptions of fear and panic; stress scale measures feelings of tension and irritability. The DASS is available in both long (42-item) and short (21-item) forms. Internal consistency of both the 42-item and 21-item versions of the questionnaire are typically above .80 and both

versions have demonstrated construct (Brown, Chorpita, Korotitsch, & Barlow, 1997; Lovibond & Lovibond, 1995) and convergent (Crawford & Henry, 2003) validity in the literature. In the present study the DASS-21 presented an equally valid and reliable option to the longer version whilst limiting respondent fatigue. Respondents were asked 'how much the statement applied to you over the past week or the last time spent in work for the fire service' and scored using a four point Likert-type scale anchored from 1 'did not apply to me at all' to 4 'applied to me very much, or most of the time'. Higher scores on each subscale are associated with increasingly severe depression, anxiety, or stress.

3.5.10 Positive and negative affect

Positive affect describes mood states where a person feels alert, enthusiastic and active, whereas negative affect describes aversive mood states such that a person reports feelings of disgust, anger, and contempt. Conversely, low positive affect scores are characterised by sadness and lethargy and low negative affect is associated with calmness and serenity. The positive and negative affect schedule (PANAS) was designed to report mood states and measures the two distinct dimensions of positive and negative affect (Watson, Clark, & Tellegen, 1988). The PANAS has been used previously among a firefighter population (Throne et al., 2000) and has alpha coefficients consistently above .70 (Crawford & Henry, 2004; Watson et al., 1988) with demonstrable validity (Depaoli & Sweeney, 2000). The PANAS includes a 20-item questionnaire scored using a five point Likert-type scale. Respondents are asked 'to what extent you have felt this way during the past week or your last time in work for the fire service' and answers were anchored from 1 'very slightly or not at all' to 5 'extremely'. Higher scores on each subscale indicate the presence of positive, or negative mood.

3.5.11 Satisfaction with life

Life satisfaction, together with positive and negative affect, are collectively described as subjective wellbeing and defined as the cognitive and affective evaluations of one's life (Diener, 1984; Diener & Emmons, 1985). Positive and negative affect, as identified using the PANAS, is concerned with

emotive aspects, whereas life satisfaction engages with cognitive-judgmental processes. The satisfaction with life scale (SWLS) was identified by separating items of affect and identifying life satisfaction items that had a factor loading above .60 and without semantic similarity (Diener, Emmons, Larsen, & Griffin, 1985) and further studies have supported discriminant validity from emotional wellbeing and convergent validity with other measures of subjective wellbeing (Pavot & Diener, 1993). The SWLS is a five-item questionnaire using a seven point Likert-type scale and respondents are asked to what extent they agree or disagree with five statements, with answers anchored from 1 'strongly disagree' to 7 'strongly agree'. A higher score is an indication of higher life satisfaction.

3.5.12 Section four: sleep

Section four required participants to report on sleep quality and daytime sleepiness as measured by the Pittsburgh sleep quality index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) and Epworth sleepiness scale (ESS) (Johns, 1991). Sleep quality is a widely measured and recognised term yet it is a difficult and complex variable to define objectively, not least because of the subjective interpretation of sleep quality and age group differences in sleep requirements (Max Hirshkowitz et al., 2015). However studies have shown the understanding of sleep quality to be similar between normal sleepers and insomniacs (Harvey, Stinson, Whitaker, Moskovitz, & Virk, 2008) and most individuals understand good sleep quality as being 'without difficulty falling asleep', and 'with sufficient duration so as to wake up rested without excessive daytime sleepiness'. Typically the term sleep quality includes quantitative measures of sleep duration, sleep latency (time to fall asleep), sleep efficiency (ratio of total time spent in bed and time spent asleep) and sleep disturbance (number and duration of awake episodes).

3.5.13 Pittsburgh sleep quality index

The most widely used self-report measure of sleep quality is the PSQI, which is designed to report on all the aforementioned sleep constructs over a one month period and also give a combined global measure of sleep quality (Buysse et al., 1989). Previous research has supported internal consistency

reliability and construct validity of the PSQI in clinical (Carpenter & Andrykowski, 1998) and non-clinical population samples (Mollayeva et al., 2016). The PSQI questionnaire includes 19 self-assessed items and 5 item questions for a sleeping partner. The self-reported questions are grouped into seven component scores weighted equally on a 0-3 scale. A global measure of sleep quality is calculated by summing the seven component scores on a 0-21 scale, such that a higher score indicates worse sleep quality (Buysse et al., 1989). In the present study, for ease of data collection as recommended by Buysse *et al*, (1989), questions intended for a sleeping partner were omitted from the survey.

3.5.14 Epworth sleepiness scale

Sleep quality as determined by use of the PSQI questionnaire does not measure daytime sleepiness. An assessment of typical daytime sleepiness is particularly important within the FRS environment due to the safety critical nature of emergency response activities. The Epworth sleepiness scale (ESS) is a self-report questionnaire of sleep propensity during common daytime situations and has demonstrated good internal consistency and validity among sleep apnea individuals reporting excessive daytime sleepiness (Johns, 1992). Daytime sleepiness has been assessed previously using the ESS among firefighter populations (Carey, Al-Zaiti, Dean, Sessanna, & Finnell, 2011) and has proven useful for predicting work-related accidents (Barger et al., 2015).

The ESS is an 8-item questionnaire using a 4-point Likert-type scale and respondents are asked how likely they are to doze off or fall asleep in a different situations, with answers anchored from 0 'would never doze' to 3 'high chance of dozing' (Johns, 1991). The test-retest reliability of the ESS has been questioned, however suitability of the ESS for population comparisons is supported (Kendzerska, Smith, Brignardello-Petersen, Leung, & Tomlinson, 2014).

3.6 Cardiovascular Disease Risk Stratification

In study 3 the FF population sample was analysed separately. The American College of Sports Medicine (ACSM) CVD risk stratification tool (Pescatello et al., 2013) was applied to the survey data. Respondents were

classed as either being at a low (<2 risk factors), moderate (≥ 2 risk factors), or high risk (pre-disclosed signs/symptoms of pulmonary, cardiovascular and/or metabolic disease) of developing atherosclerotic CVD. Risk factors included age (men ≥ 45 yr; women ≥ 55 yr), cigarette smoking (current smoker or cessation ≤ 6 months), sedentary lifestyle (≤ 900 Met·mins·week⁻¹), obesity (BMI ≥ 30 kg·m⁻² or WC > 102cm, men; > 88cm, women), hypertension (pre-disclosed on health and lifestyle survey), dyslipidemia (pre-disclosed on health and lifestyle survey) and pre-diabetes (assumed if; age ≥ 45 yr and BMI ≥ 25 kg·m⁻² or age <45yr and BMI ≥ 30 kg·m⁻²).

3.7 Blood sampling

3.7.1 Participant consent

At the end of the health and lifestyle survey participants gave informed consent for future research (Study 4). A population sample was selected from willing participants reporting as operational firefighters (FF) such that both northern and southern FRS UK regions represented the sample. Respective FRSs were approached to facilitate blood sampling within the fire stations.

Following consent at the organisational level, arrangements were made to visit participating fire stations and facilitate an open discussion regarding the research project. On completion of each discussion all potential participants were given a participant information sheet (Appendix. D) and consent form (Appendix. E). Participant consent and arrangements for a revisit were confirmed with each fire station.

3.7.2 Anthropometry

A private room at each fire station was made available to improve participant privacy and comfort. A standardised protocol was used wherein height was measured using a clinical stadiometer (Seca 216; Leicester UK) and body mass was assessed using calibrated weighing scales (Seca; Hamburg Germany). During data collection, firefighters wore light clothing and no shoes. Body fat percentage was predicted using a bioelectrical impedance method (BIA) (Bodystat 1500, Isle of Man). Studies have shown assessment of body

composition using BIA methods to have acceptable reliability and validity (Bolanowski & Nilsson, 2001).

3.7.3 Blood samples

At participant fire stations, blood samples were obtained by venipuncture from an antecubital vein using a needle and vacutainer system (BD Diagnostics, Becton, Dickinson and Co.). Each blood sample was collected using one untreated tube (6 mL) and one tube (6 mL) containing ethylenediaminetetraacetic acid (EDTA). All samples were taken upon waking (07.00-08.00 hours) and participants were advised to fast and refrain from smoking or strenuous physical activity prior to providing a sample.

3.7.4 Biochemical analyses

Commercially available enzyme immunoassays (R&D Systems Inc., Abingdon, UK) were used to measure serum concentrations of IL-6 (Sensitivity 0.04 pg·mL⁻¹; CV 7.4%) and TNFα (Sensitivity 0.191 pg·mL⁻¹; CV 8.7%). C-reactive Protein (CRP), total cholesterol (TC) and concentrations of high-density lipoprotein (HDL-C), triglycerides (TRG) and non-esterified fatty acids (NEFA) were measured using an automated spectrophotometer (Daytona, Randox Laboratories, Northern Ireland). All standards and samples were examined in duplicate.

The Friedewald equation was used to predict low density lipoprotein LDL for concentrations in mmol.L⁻¹ shown below:

$$LDL \approx TC - HDL - 0.45TRG$$

Where TC is total cholesterol and TRG is concentration of triglycerides. For triglyceride levels above 4.5 mmol.L⁻¹ the Friedewald equation loses accuracy, so data were not included in these instances.

CHAPTER 4

Study 1

Lifestyle Behaviours and Perceived Wellbeing in Different Fire and Rescue Service Roles

4.1 Introduction

Compared to non-shift workers, shift workers are reported to be at an increased risk of chronic disease (Torquati, Mielke, Brown, & Kolbe-Alexander, 2018). Approximately one-third of the UK working population are shift-workers; defined as working shift patterns outside the hours of 7am to 7pm (Department of Health, 2014). Typically one-fifth of workers are employed on shift work that involves night work (Harrington, 2001) and night work exposure is associated with adverse psychological states (Beltagy, Pentti, Vahtera, & Kivimaki, 2013). Compared to non-shift workers, shift workers are, on average, more likely to smoke, consume less fruit and vegetables and have a higher BMI (Department of Health, 2014). Whether an increased risk of chronic disease among shift-workers is due to shift working patterns per se, or to the prevalence of unhealthy lifestyle behaviours, remains unclear.

While shift work does not appear to pose acute health risks, prolonged periods of shift-working have adverse effects on perceived wellbeing (Lopresti et al., 2013) and sleep quality (Chandola, Ferrie, Perski, Akbaraly, & Marmot, 2010). Furthermore, short sleep duration has been shown to increase sympathetic nervous system activity and blood pressure (Gangwisch et al., 2006) and is perhaps exacerbated in the presence of sleep disruption (Chandola et al., 2010). Sleep disruption in shift-workers may, in part, be explained by circadian rhythm misalignment resulting from alterations in day-night signaling processes, leading to a decrease in resting metabolic rate and altered blood glucose concentrations (Buxton et al., 2012). A decrease in energy expenditure and fatigue-induced reductions in PA may contribute to the prevalence of overweight and obesity observed in shift workers, compared to non shift workers (Buchvold, Pallesen, Waage, & Bjorvatn, 2017).

Alterations to lifestyle behaviours such as PA and dietary intake among shift-workers may have further consequences for psychological wellbeing (Lopresti et al., 2013) and perhaps reduce the reported benefits of positive

wellbeing (Huppert, 2001). Yet in physically demanding occupations such as firefighting, transient increases in cardiac risk occur during emergency response activity and are often coupled with undiagnosed cardiovascular disease (CVD) and unfavourable lifestyle behaviours (Soteriades, Smith, et al., 2011). However, among firefighting populations, the use of physical entry standards and health screening could help maintain a healthy worker effect (Choi, 2000) that buffers against the negative effects of shift-working and encourages applications from individuals with psychological characteristics more suited to the challenges of emergency response.

Occupations within the UK Fire and Rescue Service (FRS) encompass contrasting job roles that, in their differences, present an opportunity to investigate the potential health effects of differing occupational stressors. Occupational roles within the UK FRS can broadly be categorised as operational firefighting (FF), emergency control (EC), and administrative support (AS). The FF role includes emergency response activity as defined by responding to, and attending, emergency incidents. This work also requires the maintenance of physical fitness commensurate to a cardiorespiratory standard of $42 \text{ ml kg}^{-1} \text{ min}^{-1}$ (Siddall et al., 2016). EC roles include emergency call handling and are predominantly office-based; while, AS roles are administrative and office-based. Both the FF and EC roles involve shift-working, whereas the AS role involves typical work in daytime hours. To date, the health characteristics, lifestyle behaviours, and wellbeing of employees performing these distinct occupational roles within the UK FRS have not been formally examined within extant empirical literature.

The aim of this study was to quantify the health characteristics, health-related lifestyle behaviours and associated measures of perceived health and wellbeing among UK FRS employees across these three distinct occupational groups. We hypothesised that FF would report more frequent healthy lifestyle behaviours and greater feelings of health and wellbeing compared with other FRS job roles that are office based (AS roles) or office based with night shift working (EC roles). We further hypothesised that reported differences in perceived wellbeing would differ according to lifestyle characteristics within each FRS role.

4.2 Methods

4.2.1 Participants

Target participants for this study were all UK FRS employees, including FF (who are shift working and engage in physically arduous emergency response), EC (who are shift working, are desk/office based without a physically arduous component), and AS personnel (who are typically not shift workers, and are office based without a physically arduous component). Participants were recruited as volunteers through internal FRS communications. All participants gave informed consent after reading a written description of the study. This study received ethical approval from the University of Bath Research Ethics Approval Committee for Health (REACH, University of Bath).

4.2.2 Health and Lifestyle Survey

A health and lifestyle survey (Appendix A) was compiled and hosted on an online survey platform (SurveyMonkey). This survey was made accessible via the UK FRS internal intranet system for a period of six months (January through July 2013). All FRS employees were invited to complete the survey in an attempt to capture data from a representative cross-section of UK FRS employees and occupational groups. Paper copies were also made available where online access was not possible.

The survey was composed of a number of reliable and previously validated questionnaires and comprised of four sections; general information [i.e. age, sex, height, body mass, waist circumference (WC), body mass index (BMI), waist to height ratio (WtHr) employment length, medical history], lifestyle (i.e. physical activity, nutrition, alcohol, smoking), psychological wellbeing (i.e. depression, anxiety, stress, mood, life satisfaction) and sleep quality (i.e. sleep behaviours, daytime sleepiness). The questionnaires (see general methods) were specifically selected based on their well-established use in occupational settings (Robinson et al., 2010) where they have demonstrated good reliability and validity. Where shortened versions of questionnaire protocols were available, they were used to manage the overall length of the survey and participant

burden without markedly affecting validity and reliability. Full details of the scoring protocols for each questionnaire can be found in Appendix B.

4.2.5 Data analysis

All statistical analyses were completed using SPSS Version 20 (IBM, New York, USA). Descriptive statistics (mean, standard deviation) were calculated for each occupational role and sex. Standardised z-scores larger than 3.29 ($p < 0.001$) were used to identify participants as univariate outliers who were then excluded from further analyses. Log transformation was performed prior to statistical analysis for all data displaying excessive skewness (≤ -2 or ≥ 2) or kurtosis (≤ -2 or ≥ 2). All data were back-transformed prior to presentation. Group differences were tested with analysis of covariance (ANCOVA), adjusting for previously identified confounding variables (Soteriades, Smith, et al., 2011). When testing for between group differences in physical activity level adjustments were made for group differences in smoking prevalence, age, sex, BMI and alcohol score. Post hoc Bonferroni methods were used to identify significant differences between subgroups following significant overall F-test results. The Welch statistic was used to test for equality of means. Chi-square analysis was conducted to test for significant differences between nominal values and Cramer's V reported for clinical meaningfulness, where a value of 0.1 is considered small, 0.3 moderate, and 0.5 or above, large (Cohen, 1988). Radar charts using standardised z-scores were used to graphically compare lifestyle behaviours and psychological wellbeing according to FRS job role. Radar plotting has been reported as an effective method to convey meaning in multivariate data using graphical presentation in health-related research (Saary, 2008).

Effect sizes were calculated to provide an assessment of the clinical meaningfulness of any group differences between continuous variables. In this regard, an effect size of 0.2 is considered small, 0.5 moderate, and 0.8 or above large (Cohen, 1988). Statistical significance was set *a priori* at $p < 0.05$ and data are presented as mean (\pm SD) unless stated otherwise.

4.3 Results

4.3.1 Respondents

A sample of UK FRS personnel (4564) responded to this survey, of which 3333 survey forms (73%) were completed (2454 male: 879 female), from a workforce of 61,720 (7.4% uptake). Responses by FRS role using the workforce base were FF; 2236 (4.4% uptake), EC; 184 (10.7%) and AS; 913 (9.9%). Descriptive data, broken down by sex, are presented in Table 4.1

4.3.2 Descriptives

The proportion of each role engaged in shift working involving night shifts were reported [89.2%: 86.2%: 26.3%; proportion engaged in weekly night shifts among FF, EC, AS, FRS roles]. After adjustment for age, sex, BMI, total weekly physical activity, smoking and alcohol consumption, hypertension ($X^2(2) = 27.67$, Cramer's $V = 0.10$; $P < 0.05$) and diabetes ($X^2(2) = 14.30$, Cramer's $V = 0.10$; $P < 0.05$) were lowest among FF, and although the prevalence of diabetes and hypertension increased progressively across BMI classifications, compared to AS and EC a less steep gradient was seen in FF. Furthermore, FF had the lowest prevalence of obesity ($X^2(2) = 6.67$, Cramer's $V = 0.05$; $P < 0.05$).

After adjustment for age, total weekly physical activity, smoking, alcohol, daily sitting time and sleep components, female FF had a significantly lower WtHr ($F=3.32$; $P < 0.05$) compared to women in EC and AS, as was hypertension prevalence ($F=6.15$; $P < 0.01$) in women FF.

Table 4.1. Descriptive statistics and medical conditions of respondents to the health and lifestyle survey organised by FRS role and sex. Data are means (\pm SD) unless otherwise stated.

Descriptive / FRS role	Occupational Role					
	Firefighter (FF)		Emergency Control (EC)		Administrative Support (AS)	
	Male	Female	Male	Female	Male	Female
n (%)	2037 (91)	199 (9)	42 (23)	142 (77)	538 (60)	375 (41)
Age (y)	43 (\pm 8)	37 (\pm 7) ^{bc}	43 (\pm 10)	42 (\pm 9) ^{ac}	44 (\pm 10)	47 (\pm 10) ^{ab}
Body mass (kg)	87 (\pm 12)	67 (\pm 10) ^{bc}	93 (\pm 15)	74 (\pm 15) ^{ac}	88 (\pm 14)	68 (\pm 13)
Height (m)	1.80 (\pm 0.06)	1.68 (\pm 0.07) ^c	1.79 (\pm 0.06)	1.66 (\pm 0.07) ^c	1.64 (\pm 0.07)	1.78 (\pm 0.07) ^{ab}
BMI (kg.m ⁻²)	27.0 (\pm 3.1)	23.5 (\pm 2.8) ^{bc}	28.6 (\pm 4.3)	26.3 (\pm 4.4) ^a	25.1 (\pm 4.2)	27.5 (\pm 3.9) ^a
< 25 n(%)	582 (28.6)	148 (74.4)	9 (21.4)	68 (47.9)	301 (\pm 56.0)	107 (28.5)
≥ 25 & ≤ 30 n(%)	1123 (55.1)	44 (22.1)	21 (50)	43 (30.3)	167 (\pm 31.0)	171 (45.6)
≥ 30 n(%)	332 (16.3)	7 (3.5)	12 (28.6)	31 (21.8)	70 (\pm 13.0)	97 (25.9)
WC (m)**	0.87 (\pm 0.07)	0.77 (\pm 0.08) ^{bc}	0.91 (\pm 0.09)	0.82 (\pm 0.12) ^a	0.79 (\pm 0.10)	0.89 (\pm 0.08) ^a
WtHr (m.m ⁻¹)**	0.49 (\pm 0.04)	0.46 (\pm 0.05) ^{bc}	0.52 (\pm 0.06)	0.50 (\pm 0.08) ^a	0.48 (\pm 0.07)	0.50 (\pm 0.05) ^a
Employment (y)	18 (\pm 8)	11 (\pm 7) ^{bc}	15 (\pm 10)	17 (\pm 10) ^a	9 (\pm 7)	16 (\pm 11) ^a
Heart condition n(%)*	40 (2)	1 (0.5)	3 (7.1)	4 (2.8)	10 (1.9)	15 (4)
Stroke n(%)*	1 (0.0)	1 (0.5)	0	0	3 (0.6)	5 (1.3)
Diabetes n(%)*	19 (0.9)	1 (0.5)	3 (7.1)	2 (1.4)	12 (2.2)	11 (2.9)
Hypertension n(%)*	155 (7.6)	7 (3.5)	8 (19)	13 (9.2)	51 (9.5)	68 (18.1)
Dyslipidemia n(%)*	5 (0.2)	1 (0.5)	0	0	1 (0.1)	0
Asthma n(%)*	5 (0.2)	0	0	3 (2.1)	9 (1.7)	7 (1.9)

Significantly different from (females) ^aFF, ^bEC, ^cAS, $p < 0.05$. *As a result of small numbers for these variables, differences are reported within the results section according to FRS role. **WC indicates waist circumference; WtHr indicates waist to height ratio.

4.3.3 Lifestyle

Lifestyle behaviours according to FRS occupational group are presented in Table 4.2 and graphically in Figure 4.1. After adjusting for age, sex, BMI, smoking and alcohol, FF reported a higher total PA ($p < 0.05$; $g = 0.54$ & 0.51 for EC and AS respectively) and less time spent sitting ($p < 0.05$; $g = 1.16$ & 0.77 for EC and AS respectively). More specifically, compared to EC, FF participated in almost twice the amount of vigorous PA ($p < 0.05$; $g = 0.47$) and rated their health more highly ($p < 0.05$; $g = 0.33$). However, FF had the highest alcohol use score of all groups ($p < 0.05$; $g = 0.36$ & 0.33 for EC and AS respectively) and most prevalent at-risk drinking behaviour (with scores ≥ 5 in 52%, 37%, and 39% for FF, EC, and AS respectively), $X^2(2) = 57.82$, Cramer's $V = 0.13$ ($p < 0.05$).

Habitual smoking was more than twice as prevalent among EC (15.3%) compared to FF (6.8%) and AS (6.6%), respectively, $X^2(2) = 18.78$, Cramer's $V = 0.10$, ($p < 0.01$). FF reported higher total dietary fat than AS employees, and higher saturated fat than both EC and AS ($p < 0.05$). Despite the different shift requirements of occupational roles, total sleep duration did not differ significantly between groups. However compared to EC and AS, FF reported greater sleep quality ($p < 0.05$; $g = 0.21$ & 0.14 for EC and AS respectively), yet higher daytime sleepiness.

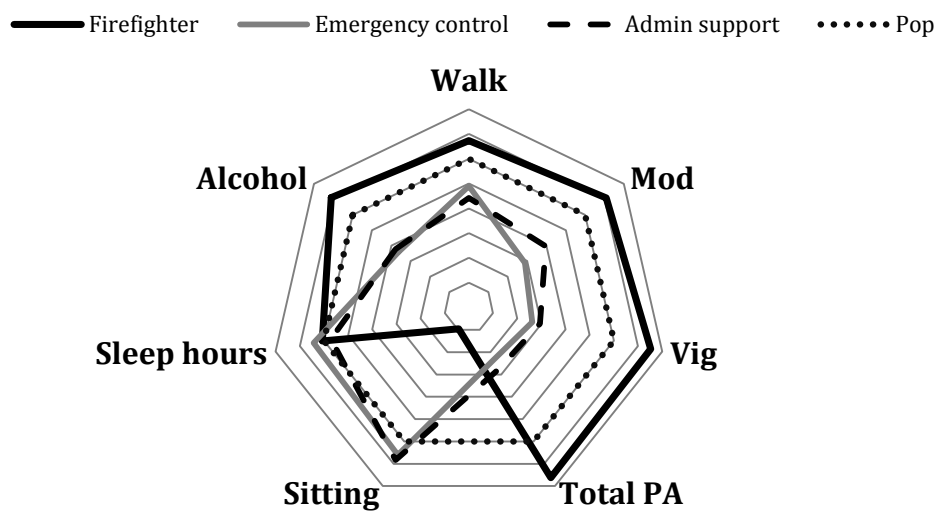


Figure 4.3 Radar plot of standardised z-scores for lifestyle behaviours among UK FRS employees grouped according to FRS job role.

Table 4.1 Lifestyle behaviours and diet according to occupational role.

Descriptive n*	Occupation Role			
	FF	EC	AS	Group differences
	2236	184	913	
<i>Physical activity</i> (MET.mins.week ⁻¹)				
Total physical activity*	4882 (±3542) ^{bc}	2992 (±2542) ^a	3185 (±2749) ^a	F=38.04; P<0.01
Vigorous physical activity*	2558 (±2639) ^{bc}	1334 (±1751) ^a	1456 (±1864) ^a	F=26.85; P<0.01
Moderate physical activity*	1368 (±2016) ^{bc}	590 (±854) ^a	821 (±1366) ^a	F=19.89; P<0.01
Walking*	1102 (±1244) ^c	943 (±962)	813 (±1016) ^a	F=14.67; P<0.01
Sitting (Mins.day ⁻¹)	302 (±163) ^{bc}	494 (±197) ^{ac}	429 (±166) ^{ab}	F=94.00; P<0.01
<i>Lifestyle behaviours</i>				
Self-rated health (1-4)**	1.9 (±0.6) ^{bc}	2.1 (±0.6) ^a	2.0 (±0.6) ^a	F=6.0; P<0.05
Sleep (hrs.night ⁻¹)	6.74 (±1.1)	6.80 (±1.4)	6.70 (±1.1)	NS
Sleep disturbance (0-3)***	1.12 (±0.5)	1.28 (±0.5)	1.22 (±0.5)	NS
Sleep quality (0-3)***	1.11(±0.7) ^{bc}	1.26 (±0.8) ^{ac}	1.01 (±0.7) ^{ab}	F=11.78; P<0.01
Sleepiness (0-24)***	5.77 (±4.2) ^c	5.44 (±3.8)	5.19 (±4.1) ^a	F=4.3; P<0.05
Smoking n(%)	152 (6.8) ^b	28 (15.3) ^{ac}	60 (6.6) ^a	F=7.87; P<0.01
<i>Diet</i>				
Alcohol (score)	4.81 (±2.4) ^{bc}	3.96 (±2.2) ^{ac}	4.01 (±2.4) ^a	F=6.17; P<0.01
Total fat (score)	37 (±6)	39 (±6)	39 (±6)	NS
Saturated fat (score)	25 (±4)	27 (±4)	27 (±4)	NS
Vegetable (≥3 servings.day ⁻¹ .week ⁻¹)	1.64 (±0.7)	1.63 (±0.7)	1.56 (±0.6)	NS
Fruit (≥2 servings.day ⁻¹ .week ⁻¹)	1.72 (±0.7)	1.69 (±0.7)	1.63 (±0.7)	NS
Grains (≥3 servings.day ⁻¹ .week ⁻¹)	1.81 (±0.7) ^{bc}	1.95 (±0.8) ^a	1.94 (±0.8) ^a	F=4.11; P<0.05
Meat (servings.week ⁻¹)	1.72 (±0.7)	1.88 (±0.7)	1.85 (±0.7)	NS

Data are means (±SD) unless otherwise stated. Significantly different from ^aFF, ^bEC, ^cAS, p<0.05. * Total n (3105), FF (2120), EC (169), AS (816) differs for all physical activity due to missing data. **A higher self-rated health score indicates poorer health. ***A higher score indicates greater sleep disturbance, and/or poorer sleep quality, and/or higher daytime sleepiness.

4.3.4 Psychological wellbeing

Psychological wellbeing score according to FRS role are presented in Table 4.3 and graphically in Figure 4.2 Internal reliability of the DAS-21 scale was calculated and found to have a very high level of reliability (Cronbach's $\alpha \geq .92$, .80, .90; for the depression, anxiety, and stress scales). Similarly, the internal reliability of the SWLS and PANAS were very high (Cronbach's $\alpha \geq .92$, .87; positive, negative affect and .90; SWLS). After adjusting for age, sex, BMI, total weekly physical activity, alcohol and smoking, psychological distress scores did not differ between FRS roles. Compared with EC, reported life satisfaction was significantly higher in FF, however the effect size was small ($p < 0.05$; $g = 0.21$).

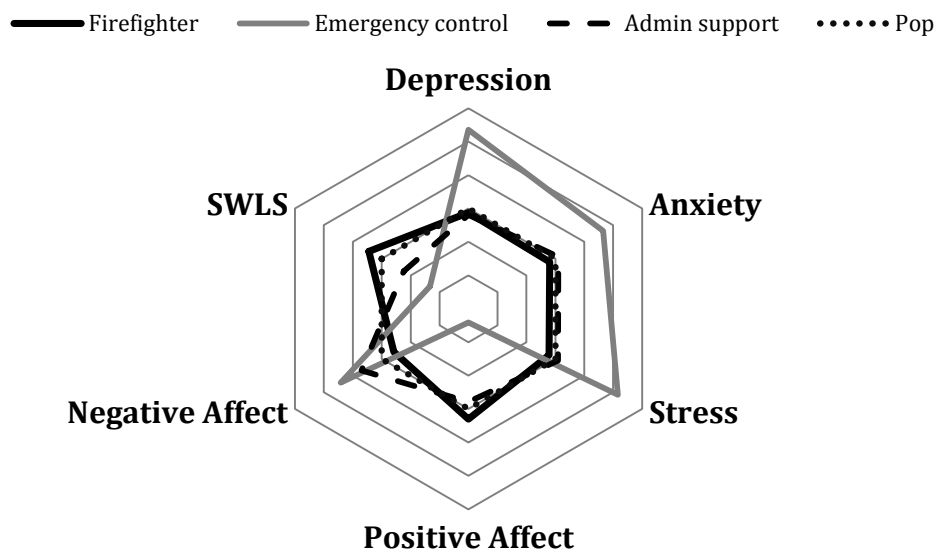


Figure 4.4 Radar plot of standardised z-scores for psychological wellbeing score among UK FRS employees grouped according to FRS job role.

Table 4. 2 Psychological wellbeing score according to FRS role. Data are means (\pm SD).

Psychological wellbeing (score) n*	FF	FRS Role		Group differences
		EC	AS	
	2169	182	881	
Depression (0-21)*	3.17 (\pm 3.9)	3.85 (\pm 4.2)	3.16 (\pm 3.8)	NS
Anxiety (0-21)*	1.55 (\pm 2.0)	1.90 (\pm 2.39)	1.57 (\pm 2.0)	NS
Stress (0-21)*	3.94 (\pm 3.9) ^b	4.79(\pm 3.8) ^{ac}	4.16 (\pm 3.8) ^b	NS
Positive affect (0-25)	16.6 (\pm 4.9) ^b	15.2 (\pm 5.2) ^{ac}	16.4 (\pm 4.7) ^b	NS
Negative affect (0-25)	6.55 (\pm 2.3) ^{bc}	6.93 (\pm 2.4) ^a	6.80 (\pm 2.4) ^a	NS
Satisfaction with life (0-35)	18.6 (\pm 7.1) ^{bc}	17.1 (\pm 7.4) ^a	17.7 (\pm 7.2) ^a	F=6.34; P<0.01

Significantly different from ^aoperational ^bcontrol, ^csupport, p<0.05.

*Total n(3232), FF(2169), EC(182), AS(881) differs for depression, anxiety, stress due to missing data.

4.4 Discussion

The findings of this study demonstrate that, compared to EC and AS FRS roles, employees in FF roles typically report more favourable lifestyle characteristics perhaps reflective of a role-specific minimum fitness standard. FF reported the highest levels of physical activity and satisfaction with life, but also the lowest prevalence of obesity and chronic medical conditions, compared to other FRS occupational groups. These findings may be used to inform FRS workplace intervention strategies.

To our knowledge, the sample represents the largest of its type to describe lifestyle behaviours and health characteristics, including psychological wellbeing and sleep characteristics, of UK FRS employees, and is the first to compare operational and non-operational FRS roles. The relative size of each occupational role within the present study reflects that found within the UK FRS general population [82%: 3%: 15%: compared with 67%: 6%: 27%; FF, EC, AS in the present study]. The sample size of female firefighters was large in comparison with previous studies and in comparison to the gender split among FRS roles.

Despite these strengths the study had a number of limitations. Participation in the study was voluntary and therefore healthier individuals may be over-represented, contributing to sample bias. The response rate of 7.6% was low, challenging the representativeness of the sample and its applicability to the wider UK FRS population. Moreover, the use of a single-source survey in our study may have lead to common-instrument bias such that the reporting of wellbeing in the study may have influenced reporting of related behaviours including self rated health, alcohol use, smoking, physical activity level. Additionally the sample size of female firefighters and particularly male emergency control workers was small and may have reduced the power of statistical analyses. Finally, the reported presence of weekly night shifts among administrative employees may have confounded group differences in health variables. Despite these limitations, this study adds descriptive information regarding health characteristics and modifiable lifestyle behaviours to current

occupational health research and draws attention to potential targets for intervention.

The lower obesity prevalence among FF in the present study is perhaps an indication of the incompatibility of excess body mass with firefighting duties. However WC was highest among FF ($p < 0.05$; $g = 0.33$ & 0.23 for AS and EC respectively), which is of some concern given the increased risk and prevalence of cardiac fatalities associated with operational firefighting duties (Geibe et al., 2008). The findings of the current study support current concerns of an upward trend in obesity prevalence among UK operational FF; reported as 11% in 2008 and 13% in 2011 (Munir et al., 2012), compared with 15% in the present study.

In the present study, FF reported the highest level of physical activity engagement ($5002 (\pm 4546)$ MET.mins⁻¹.week⁻¹) and lowest daily sitting time, in the presence of lower prevalence of obesity and hypertension, when compared with other occupational groups. This is in agreement with previous research among a US firefighter population where the use of a wellness program was associated with higher reported physical activity and a lower prevalence of obesity and hypertension (Poston et al., 2013). Indeed, the mean reported physical activity levels in FF were five-fold higher than the current recommended minimum weekly physical activity level for health maintenance (Department of Health, 2011). Most FF (90%) reported at least the minimum weekly physically activity amount (≥ 900 MET.mins⁻¹.week⁻¹) compared to EC (76%) and AS (76%). Given the physical demands of firefighting it is encouraging that firefighters are achieving substantially higher physical activity levels, perhaps more appropriate for maintaining the levels of cardiorespiratory fitness (Siddall et al., 2016), muscular strength and endurance (Stevenson et al., 2017) necessary to fight fires safely and effectively.

The association between physical activity and psychological wellbeing may be related to favourable stimulatory effects on the hippocampus, an area of the brain sensitive to the effects of ageing and cognitive impairment and important for learning, memory and motivation (Cotman et al., 2007). It may also act by improving sleep quality, through thermoregulatory processes affecting melatonin release (Cotman et al., 2007). Despite differing shift-patterns, total sleep hours were unexpectedly similar between groups in the present study

perhaps due to a higher-than-expected prevalence of reported night shift working among the AS group. Interestingly, EC reported the highest sleep disturbance and lowest sleep quality of all roles perhaps reflecting differences in night-shift duties compared to other FRS roles. The substantial habitual physical activity among FF and possible beneficial impact on sleep quality may partly explain the greater perceived psychological wellbeing and satisfaction with life compared with other FRS roles. In addition, this suggests habitual physical activity may counteract some of the negative effects of shift work on wellbeing and that important differences in sleep behaviour may be independent of sleep duration. The acute moderating effect of physical fitness on stress reactivity has been demonstrated previously in a firefighter cohort (Throne et al., 2000). However irrespective of role, components of sleep and self-rated health were independently associated with psychological wellbeing. In previous studies single item global self-rated health measurement has shown consistent association with overall mortality and psychological wellbeing even after adjustment for comorbid illness (DeSalvo, Bloser, Reynolds, He, & Muntner, 2010).

In the present study, differences in nutritional behaviour were not judged to be clinically meaningful. However, in agreement with findings among US firefighter populations (Haddock et al., 2012), compared to EC (38%) and AS (39%), a higher proportion of FF (52%) reported 'at-risk' alcohol consumption. Alcohol consumption has been observed previously as a coping strategy for the psychological demands of emergency response work (Haddock et al., 2012). Indeed, there are consistent findings and agreement that firefighters may present as an 'at-risk' group for alcohol consumption (Piazza-Gardner et al., 2014).

In summary, participants in this study that were engaged in more physically arduous FRS roles (i.e. operational firefighters), reported higher levels of physical activity, higher life satisfaction and lower prevalence of medical conditions associated with cardiovascular health. Conversely, night shift-workers, not involved in physically arduous emergency response activities (i.e. emergency control), reported the lowest weekly physical activity amount, highest daily sitting time, lowest life satisfaction and self-rated health.

CHAPTER 5

Study 2

Determinants of Psychological Wellbeing in Fire and Rescue Service Personnel

5.1 Introduction

Responses to a health and lifestyle survey according to occupational role were described among a UK Fire & Rescue Service (FRS) population (Chapter 1). However, further analysis is required to identify associations between individual lifestyle behaviours, health characteristics and psychological wellbeing. Furthermore, identifying independent determinants of psychological wellbeing would likely inform development of appropriate interventions to assist employees involved in emergency response.

Specific lifestyle behaviours, including higher physical activity levels (Anderson et al, 2013), fruit and vegetable intake (Bertoia et al, 2015), no smoking (Messner & Bernhard, 2014) and moderate or less alcohol intake (Wood et al., 2018), are associated with more favourable indices of cardio-metabolic health (Bulló et al., 2011; Loef & Walach, 2012) and psychological wellbeing (Boehm and Kubzansky, 2012). This is typically characterised by body mass index (BMI) and waist circumference (WC) (WHO, 2008) and a lower prevalence of depression, anxiety and stress (Lopresti, Hood & Drummond, 2013) and chronic disease (WHO, 2003). Improvements in cardio-metabolic health and psychological wellbeing are likely addressed by modifying specific behavioural risk factors (Spring et al, 2014) in the context of environmental influences (Swinburn et al., 2011).

Occupation is an established factor in determining the global burden of chronic disease and important for health analysis at the population level, with both job role and working practices influential determinants of the global non-communicable disease (NCD) burden (GBD, 2013). Compared to non shift-workers, shift-workers are widely reported to be at an increased risk of chronic disease (Vyas et al, 2012; Haupt et al, 2008). Although heterogeneity in study design and outcome measures make general conclusions problematic (Wang et al, 2011), shift-work and/or sleep disruption can result in circadian rhythm misalignment and metabolic dysfunction (Buxton et al, 2012). Furthermore,

shift-work is associated with increased circulating concentrations of systemic inflammatory biomarkers (Jackowska, Kumari and Steptoe, 2012) perhaps through altered lifestyle behaviours (Peplonska et al, 2014), job strain (Wong et al, 2012) and/or social stress (Pisarski et al, 2006; Newey & Hood, 2004). Sleep deprivation prevalence has been measured at 60% among a US Firefighter population (Carey et al, 2011), which may increase sensitivity to emotional trauma in this group. As emergency response personnel are exposed to a combination of physical (Siddall et al, 2016) and psychological stressors (Murphy et al, 2002) in the normal course of their duties, it is possible that shift-working practices increase the likelihood that such physical and psychological challenges are encountered during periods of sleep deficit. This has potentially serious implications as sleep disruption is recognised as a physiological stressor that impairs brain neurogenesis, increases systemic inflammation and has adverse consequences for metabolic function (Lucassen et al, 2009).

There are three distinct occupational roles within the UK FRS that can broadly be described as operational firefighters (FF), emergency control (EC) and administrative support (AS). The FF role includes emergency response activity as defined by responding to, and attending, emergency incidents, but also requires the maintenance of physical fitness; EC role includes emergency call handling and is predominantly office-based; and AS role is administrative and office-based. Both the FF and EC roles involve shift working whereas the AS role involves typical working daytime hours. It has recently been suggested that employees engaged in distinct FRS roles differ in their lifestyle behaviour, health characteristics and psychological wellbeing (Chapter 1). However, it is not clear how these factors are related and in particular their effect on wellbeing.

Therefore the aim of this study was to investigate potential associations between individual lifestyle behaviours, health characteristics and self-report states of psychological health and wellbeing across distinct occupational groups in a sample of UK FRS personnel and test for independent determinants of psychological wellbeing. We hypothesised that increasing amounts of weekly physical activity and lower daily sitting time would be associated with more favourable health characteristics, a lower incidence of chronic disease and higher wellbeing. We further hypothesised that various indices of sleep (sleep duration,

sleep disturbance, sleep quality, sleepiness) would be associated with perceived wellbeing and this relationship would be further attenuated among employees involved in shift work.

5.2 Methods

5.2.2 Participants

Participants for this study were UK FRS employees, which included both operational (FF: Operational firefighter) and non-operational (EC: Emergency control; AS: Administrative support) employees. Participants were presented with a full written description of the study on the first page of a survey before giving consent (by tick box) to participate. This study received approval from the Research Ethics Approval Committee for Health (REACH, University of Bath).

5.3.3 Protocol

A health and lifestyle survey (Appendix. A) was made accessible online via fire station intranet systems and FRS websites, for a period of six months (Jan-July 2013), to capture data from a representative cross-section of the FRS population. Paper copies were also made available when online access was not possible.

5.3.4 Health and Lifestyle Survey

A Health and Lifestyle Survey was constructed using a number of reliable and previously validated questionnaires. The survey was designed to collect self-report information on lifestyle behaviours (physical activity, nutrition, smoking, alcohol and sleep quality), health characteristics (BMI, WC) and psychological wellbeing as well as other descriptive information. Questionnaires were selected based on their well-established use in occupational settings and their psychometric properties, demonstrating good reliability and validity. Where shortened versions of questionnaire protocol were available without markedly affecting validity and reliability, they were used to manage the overall length of the survey.

The survey was composed of four sections; general personal information; lifestyle [physical activity (International Physical Activity Questionnaire; IPAQ; Schembre & Riebe, 2011), nutrition (Rapid Eating Assessment for Patients; REAP; Segal-Isaacson, Wylie-Rosett & Gans, 2004), smoking (Cigarette Dependence Scale; CDS; Etter, Houezec & Perneger, 2003), alcohol (Alcohol Use Identification Test-C; AUDIT-C; Reinert & Allen, 2007)]; psychological wellbeing [depression, anxiety, stress (Depression, Anxiety, Stress Scale; DASS; Henry & Crawford, 2005), mood (Positive and Negative Affect Scale; PANAS; Watson, Clark & Tellegen, 1988), general life satisfaction (Satisfaction with Life Scale; SWLS; Diener et al, 1985)]; sleep [sleep quality (Pittsburgh Sleep Quality Index; PSQI; Buysse et al, 1988) and; sleepiness (Epworth Sleepiness Scale; ESS; Johns, 1988)]. The health and lifestyle survey is explained in more detail elsewhere (see general methods)

5.3.5 Data analysis

All statistical analyses were completed using IBM SPSS Version 20 (IBM, New York, USA). Descriptive statistics (mean, standard deviation) for the sample and subgroups of the sample (All FRS; operational, control or support staff) are described elsewhere (Chapter 1). For continuous variables, Pearson's correlation coefficients were calculated to identify potential associations between health characteristics, lifestyle behaviours and psychosocial constructs. Stepwise multiple regression analysis was conducted to determine which variables were most predictive of psychological distress and psychological wellbeing for the whole sample.

Standardised z-scores larger than 3.29 ($p < 0.001$) and mahalanobis distances greater than $X^2(df)$ were used to identify participants as univariate and multivariate outliers (Tabachnick & Fidell, 2007). A varying number of participants were removed on this basis. As such the final sample size (n) differed according to FRS role, dependent variable and number of predictor variables (df) in each regression equation.

A Cooks distance of 0.027 was used to identify 36 cases (1.8%) as having a residual value ± 3 but as not having an oversized influence on the regression models (Tabachnick & Fidell, 2007).

Depression, anxiety and stress scores were summed for a composite DASS-21 (Henry & Crawford, 2005). A combined DASS-21 and SWLS were used separately to represent global measures of psychological distress (Henry & Crawford, 2005) and positive psychological wellbeing (Boehm & Kubzansky, 2005) across all job roles and treated as additional dependent variables.

Internal reliability of the DAS-21 scale was calculated (chapter 1) and found to have a very high level of reliability (Cronbach's $\alpha \geq .92$, .80, .90; for the depression, anxiety, and stress scales). Similarly, the internal reliability of the SWLS and PANAS were very high (Cronbach's $\alpha \geq .92$, .87; positive, negative affect and .90; SWLS).

Multiple linear regression was conducted using the stepwise method, such that only statistically significant correlations were included and combination of variables that produced the highest R^2 . Non-standardised beta correlation coefficients were used to construct prediction equations for psychological distress and psychological wellbeing for the whole sample. Statistical significance was set at $p < 0.05$.

5.3 Results

5.3.1 Respondents

A health and lifestyle survey was completed by 3333 UK FRS employees (2454 male, 879 female). Respondents were employed in one of three distinct FRS roles: operational firefighter [FF; 2236 (67%)], emergency control [EC; 184 (6%)] and administrative support [AS; 913 (27%)]. See Chapter 1 for mean descriptive comparisons.

5.3.2 Descriptive characteristics and lifestyle behaviours

Correlations between descriptive characteristics and lifestyle behaviours were calculated for the sample (Table 5.1) according to FRS role (Table 5.2). Irrespective of FRS role, vigorous physical activity tended to decrease with increasing WHtR ($R \geq -0.13$, $p < 0.01$). Daily time spent sitting tended to decrease with increasing PA, irrespective of FRS role ($R \geq 0.20$, $p < 0.01$). Among AS only, alcohol score tended to increase with age ($p < 0.01$). Sleep hours tended to

decrease with age irrespective of FRS role and separating the population by age showed significant differences in sleep hours (6.62 hours for <45 years group; 6.96 hours for ≥45 years group) ($p < 0.01$). Among FF only, vigorous physical activity tended to decrease and sitting time increased with age, but the correlation was weak ($p < 0.01$). (age-related correlations not reported in table). There were no significant correlations between nutritional choice and other lifestyle behaviours or health characteristics.

Table 5.1 Pearson correlation coefficients between respondent descriptives and lifestyle behaviours among UK FRS.

Variable	WHtR	BMI	Waist	SRH ²
Total PA ¹	-0.11**	-0.05**	-0.04*	-0.21**
Vigorous PA	-0.17**	-0.10**	-0.07**	-0.30**
Moderate PA	-0.04*	-0.02	-0.01	-0.10**
Walking	-0.04*	-0.03	-0.01	-0.06**
Sitting	0.12**	0.05*	0.03	0.12**
Alcohol	0.03	0.08**	0.12**	0.02
SRH ²	0.29**	0.26**	0.22**	-
<i>Sleep</i>				
Duration	-0.07**	-0.09**	-0.07**	0.14**
Disturbance	0.10**	0.06**	0.03	0.20**
Quality	0.02	0.05**	0.03	0.22**
Sleepiness	0.11**	0.09**	0.10**	0.11**

* Denotes significance at $p < 0.05$; ** Denotes significance at $p < 0.01$. ¹ PA denotes total weekly physical activity. ²SRH Denotes self-rated health

Table 5.2 Pearson correlation coefficients between respondent descriptives and lifestyle behaviours, according to FRS role.

Role	Firefighter (FF)				Emergency control (EC)				Administrative support (AS)			
Variable	WH _t R	BMI	Waist	SRH ²	WH _t R	BMI	Waist	SRH ²	WH _t R	BMI	Waist	SRH ²
<i>Physical activity</i>												
Total PA ¹	-0.11**	-0.10**	-0.15**	-0.19**	-0.23**	-0.14	-0.21**	-0.28**	-0.07	-0.01	0.00	-0.17**
Vigorous PA	-0.17**	-0.12**	-0.12**	-0.28**	-0.30**	-0.25**	-0.26**	-0.30**	-0.13**	-0.08*	-0.04	-0.27**
Moderate PA	-0.05*	-0.05*	-0.05*	-0.09**	0.01	-0.01	-0.01	-0.07	-0.01	-0.01	0.02	-0.06
Walking	-0.03	-0.06**	-0.03	-0.03**	-0.07	0.03	0.02	-0.07	-0.05	0.01	-0.02	-0.08*
Sitting	0.14**	0.11**	0.15**	0.08**	0.03	0.06	0.10	0.02	-0.08*	0.05	0.03	0.08*
Alcohol	0.06**	0.08**	0.08**	0.07**	0.04	0.07	0.07	-0.09	0.02	0.06	0.13**	0.01
SRH ²	0.30**	0.28**	0.26**	-	0.42**	0.40**	0.43**	-	0.26**	0.24**	0.20**	-
<i>Sleep</i>												
Duration	-0.09**	-0.10**	-0.08**	-0.13**	0.09	0.05	0.08	-0.07	-0.09**	-0.14**	-0.11**	-0.16**
Disturbance	0.07**	0.07**	0.06**	0.19**	0.11	0.04	0.06	0.19*	0.12**	0.11**	0.05	0.18**
Quality	0.03	0.06**	0.02	0.24*	-0.10	-0.11	0.10	0.15*	0.05	-0.07*	-0.03	0.23**
Sleepiness	0.08**	0.08**	0.06**	0.12**	0.13	0.03	0.09	0.02	0.16**	0.12**	0.15**	0.14**

* Denotes significance at $p < 0.05$; ** Denotes significance at $p < 0.01$. ¹ PA denotes total weekly physical activity. ²SRH Denotes self-rated health

5.3.3 Psychological wellbeing

Correlational analysis was completed between selected descriptive characteristics, lifestyle behaviour and psychosocial constructs of wellbeing in FF (Table 5.2), EC (Table 5.3) and AS (Table 5.4). Meaningful correlation results were only achieved between reported sleep characteristics, life satisfaction, self-rated health and psychosocial constructs ($p < 0.05$).

Among all FRS roles, sleep duration was negatively associated with depression, anxiety, stress scores ($R > -0.21$, $p < 0.01$) and negative affect score for EC and AS only ($R > -0.19$, $p < 0.01$), with the strongest correlation among EC ($p < 0.01$). Among all FRS roles, a higher positive affect score was associated with increased sleep ($R > 0.13$, $p < 0.01$) and greater life satisfaction among FF and AS only ($R > 0.13$, $p < 0.01$). Across all FRS roles, higher self-rated health was associated with lower reported psychological distress (depression, anxiety, stress; negative affect, $p < 0.05$) and higher reported psychological wellbeing (satisfaction with life; positive affect, $p < 0.05$).

Table 5.3 Pearson correlation coefficients between descriptives, lifestyle behaviours and psychological wellbeing among UK FRS

Variable	Depression	Anxiety	Stress	Positive affect	Negative affect	SWL ¹
BMI	0.10**	0.05**	0.06**	0.01	0.04*	-0.10**
Body mass	0.04*	0.02	0.02	0.04*	-0.00	-0.06**
WC	0.04*	0.02	0.03	0.02	0.01	-0.05**
WHtR	0.08**	0.09**	0.09**	-0.01	0.05**	-0.08**
SRH ²	0.24**	0.24**	0.24**	-0.22**	0.15**	-0.27**
<i>Physical activity</i>						
Total PA	-0.07**	-0.07**	-0.09**	0.07**	-0.09**	0.08**
Vigorous PA	-0.08**	-0.07**	-0.09*	0.09**	-0.08**	0.10**
Moderate PA	-0.03	-0.04*	-0.04*	0.06*	-0.07**	0.07**
Walking	-0.05*	-0.07**	-0.03	0.04*	-0.06**	0.05*
Sitting	0.07**	0.05**	0.08**	-0.06**	0.04	-0.08**
<i>Diet</i>						
Alcohol	-0.05	0.06**	0.05*	-0.04	0.02	-0.00
Total fat	-0.08**	-0.10**	-0.09**	0.08**	-0.06**	0.08**
Saturated fat	-0.07**	-0.10**	-0.07**	0.07**	-0.05**	0.07**
Vegetable	0.09**	0.06**	0.09**	-0.08**	0.05*	-0.11**
Fruit	0.09**	0.08**	0.07**	-0.08**	0.04	-0.12**
Grains	0.06**	0.04*	0.05**	-0.07**	0.02	-0.07**
Meat	0.00	-0.02	0.01	0.00	-0.01	0.00
<i>Sleep</i>						
Sleep duration	-0.24**	-0.18**	-0.27**	0.14**	-0.13**	0.28**
Sleep disturbance	0.26**	0.29**	0.29**	-0.18**	0.20**	-0.25*
Sleep quality	0.35**	0.29**	0.38**	-0.26**	0.20**	-0.35**
Sleepiness	0.23**	0.23*	0.23*	-0.15**	0.18**	-0.16**

*Denotes significance at $p < 0.05$. ** Denotes significance at $p < 0.01$. ¹SWL denotes satisfaction with life; ²SRH denotes self-rated health

Table 5.4 Pearson correlation coefficients between descriptives, lifestyle behaviours and psychological wellbeing among FF

Variable / psychosocial wellbeing	Depression	Anxiety	Stress	Positive affect	Negative affect	SWL ¹
BMI	0.11**	0.05**	0.09**	0.00	0.06**	-0.10**
Body mass	0.07**	0.02	0.05*	0.00	0.02	-0.08**
WC	0.06**	0.03	0.05*	0.00	0.03	-0.07**
WH _t R	0.10**	0.06**	0.09**	0.00	0.04*	-0.08**
SRH ²	-0.27**	-0.27**	-0.26**	0.24**	-0.18**	-0.26**
<i>Physical activity</i>						
Total PA	-0.09**	-0.09**	-0.09**	0.07**	-0.10**	0.07**
Vigorous PA	-0.09**	-0.08**	-0.08*	0.08**	-0.08**	0.09**
Moderate PA	-0.04*	-0.05*	-0.04*	0.05*	-0.08**	0.07**
Walking	-0.05*	-0.07**	-0.03	0.04*	-0.06**	0.05*
Sitting	0.10**	0.05*	0.10**	-0.04	0.04	-0.08**
<i>Nutrition</i>						
Alcohol	0.05*	0.06**	0.05*	-0.04	0.06*	0.00
Total fat	-0.08**	-0.10**	-0.08**	0.10**	-0.07**	0.07**
Saturated fat	-0.07**	-0.09**	-0.06**	0.09**	-0.06**	0.06**
Vegetable	0.10**	0.09**	0.10**	-0.08**	0.07**	-0.10**
Fruit	0.12**	0.10**	0.09**	-0.10**	0.05*	-0.13**
Grains	0.06**	0.07**	0.05*	-0.06**	0.04	-0.06**
Meat	0.02	-0.02**	0.00	-0.01	-0.03	0.00
<i>Sleep</i>						
Sleep duration	-0.34**	-0.15**	-0.31**	0.20**	-0.18**	0.20**
Sleep disturbance	0.33**	0.20**	0.28**	-0.21**	0.16*	-0.15*
Sleep quality	0.36**	0.23**	0.35**	-0.25**	0.17**	-0.25**
Sleepiness	0.11	0.18*	0.16*	0.03	0.11	-0.01

*Denotes significance at p<0.05. ** Denotes significance at p<0.01. ¹SWL denotes satisfaction with life; ²SRH denotes self-rated health

Table 5.5 Pearson correlation coefficients between descriptives, lifestyle behaviours and psychological wellbeing among EC

Variable / psychosocial construct	Depression	Anxiety	Stress	Positive affect	Negative affect	SWL ¹
BMI	-0.03	0.02	0.02	0.06	-0.10	-0.06
Body mass	0.03	0.10	0.05	0.13	-0.03	-0.10
WC	0.01	0.03	0.02	0.07	-0.07	-0.11
WH _t R	-0.05	-0.01	0.02	0.09	-0.06	-0.07
SRH ²	-0.19*	-0.17*	-0.19*	0.10	0.12	-0.36**
<i>Physical activity</i>						
Total PA	-0.03	0.07	-0.04	0.06	0.00	0.14
Vigorous PA	-0.00	-0.02	-0.07	0.04	0.00	0.13
Moderate PA	-0.06	0.03	0.00	0.19**	-0.06	0.15*
Walking	-0.01	0.12	0.01	0.06	0.07	0.04
Sitting	0.03	0.08	0.09	0.07	0.19*	-0.06
<i>Nutrition</i>						
Alcohol	0.05	-0.11	-0.12	-0.10	-0.16*	0.05
Total fat	-0.07	-0.07	-0.03	0.02	-0.08	0.13
Saturated fat	-0.10	-0.08	-0.03	0.03	-0.03	0.10
Vegetables	0.07	-0.07	0.08	-0.12	-0.03	-0.28**
Fruit	-0.05	-0.07	-0.04	0.02	-0.10	-0.05
Grains	-0.03	-0.07	0.01	-0.04	-0.01	0.02
Meat	-0.03	0.03	0.08	-0.07	-0.03	-0.05
<i>Sleep</i>						
Sleep duration	-0.34**	-0.15*	-0.30**	0.21**	-0.18*	0.20**
Sleep disturbance	0.33**	0.20**	0.28**	-0.21**	0.16*	-0.15*
Sleep quality	0.36**	0.23**	0.35**	-0.25**	0.17*	0.25**
Sleepiness	0.11	0.18*	0.16*	0.03	0.11	-0.01

*Denotes significance at $p < 0.05$. ** Denotes significance at $p < 0.01$. ¹SWL denotes satisfaction with life; ²SRH denotes self-rated health

Table 5.6 Pearson correlation coefficients between descriptives, lifestyle behaviours and psychological wellbeing among AS.

Variable / psychosocial construct	Depression	Anxiety	Stress	Positive affect	Negative affect	SWL ¹
BMI	0.05	0.07*	0.03	0.02	0.06	-0.06
Body mass	0.02	0.01	-0.02	0.06	0.01	-0.06
WC	0.04	0.06**	0.02	0.05	0.03	-0.05
WH _t R	0.08*	0.15**	0.09*	-0.03	0.07*	-0.08*
SRH ²	0.23**	0.24**	0.22**	-0.18**	-0.16**	-0.27**
<i>Physical activity</i>						
Total PA	-0.02	-0.03	-0.07*	0.06	-0.01	0.03
Vigorous PA	-0.05	-0.05	-0.10**	0.08*	0.00	0.07*
Moderate PA	0.03	-0.02	-0.01	0.03	0.00	0.01*
Walking	0.01	-0.01	-0.01	0.01	0.00	0.03
Sitting	-0.02	0.05	0.02	-0.07*	-0.04	-0.04
<i>Nutrition</i>						
Alcohol	0.07*	0.02	0.05	-0.03	-0.01	-0.02
Total fat	-0.10**	-0.14**	-0.13**	0.05	-0.07*	0.13**
Saturated fat	-0.10**	-0.13**	-0.11**	0.06	-0.06	0.11**
Vegetables	0.07	0.03	0.08*	-0.06	0.03	-0.12**
Fruit	0.05	0.05	0.07*	-0.05	0.06	-0.11**
Grains	0.06	0.01	0.04	-0.07*	-0.02	-0.08*
Meat	-0.05	-0.06	-0.01	0.08*	0.00	0.03
<i>Sleep</i>						
Sleep duration	-0.24**	-0.15**	-0.26**	0.17**	-0.13**	0.27**
Sleep disturbance	0.25**	0.28**	0.24**	-0.14**	0.14**	-0.22**
Sleep quality	0.26**	0.23**	0.31**	-0.24**	0.13**	-0.34**
Sleepiness	0.27**	0.30**	0.28**	-0.17**	0.18**	-0.15**

*Denotes significance at $p < 0.05$. ** Denotes significance at $p < 0.01$. ¹SWL denotes satisfaction with life; ²SRH denotes self-rated health

5.3.4 Regression analyses

Similar relationships between sleep, self-rated health, and psychological constructs were found irrespective of FRS role and as such regression analysis was completed for the complete population. It should be noted that higher scores for self-rated health, sleep quality, sleep disturbance indicate poorer health, lower sleep quality and higher sleep disturbance.

Multiple linear regression analyses identified sleep duration, disturbance and quality, sleepiness, and self-rated health as independent predictors of psychological distress (DAS composite score) and psychological wellbeing (SWLS score). These multivariate models are fully described in Table 5.10

Table 5.7 Regression models for psychological distress (depression, anxiety, stress) and psychological wellbeing (satisfaction with life) among UK FRS employees.

Dependent variable; reported psychological distress (DAS composite score)					
Predictor variable	F	R ²	β	t	Sig
	226.86	.23			
Sleep quality			.27	14.9	P<0.001
Sleepiness			.17	10.46	P<0.001
Self-rated health			.16	9.83	P<0.001
Sleep disturbance			.14	8.11	P<0.001
Dependent variable; reported psychological wellbeing (satisfaction with life)					
Predictor variable	F	R ²	β	t	Sig
	147.96	.18			
Sleep quality			-.21	-10.35	P<0.001
Self-rated health			-.19	-11.65	P<0.001
Sleep duration			.10	-5.23	P<0.001
Sleep disturbance			-.08	-4.60	P<0.001
Sleepiness			-.07	-4.58	P<0.001

5.4 Discussion

The aim of this study was to test for independent determinants of perceived wellbeing among employees exposed to differing occupational roles. Respondents to a health and lifestyle survey were grouped according to three distinct roles within the UK FRS; operational employees (FF), emergency control employees (EC), administrative support employees (AS) that differ in their physical and nocturnal/shift job requirements. Sleep (duration, disturbance, quality, sleepiness) and SRH were significant independent determinants of psychological wellbeing irrespective of job role. Although FRS job roles differ in their shift-working requirements and reported physical activity, this did not appear to influence the relationship between psychological wellbeing/distress, sleep and SRH.

This study improves on existing literature by describing the relationships between various lifestyle behaviours, health characteristics and perceived wellbeing among employees in differing occupational roles and identifying independent predictors of wellbeing. Although related components of sleep were only moderately correlated with reported psychological wellbeing, in the context of the present study sleep was a prominent influence on both psychological distress and wellbeing.

The importance of sleep for both physical and psychological wellbeing is well documented (Antunes et al., 2010; Atkinson & Davenne, 2007; Foti, Eaton, Lowry, & McKnight-Ely, 2011; Jennings et al., 2007). The economic cost of inadequate sleep to the workplace is considerable (Vincent, Kinchin, Ferguson, & Jay, 2018). It is somewhat surprising therefore that sleep behaviour receives less attention than other lifestyle behaviours in the context of health promotion and risk management within the occupational setting (Rosekind, 2005). Recent research has investigated the metabolic consequences of sleep deprivation similar to that of shift working and reported a drop in resting metabolic rate lasting 9 days (Buxton et al., 2012). The findings may have relevance for FF engaged in frequent night-shifts [90% involved in weekly night-shifts (chapter 1)], with varying recovery periods (1-4 days) and unpredictable periods of emergency response activity. In the present study, among FF and AS, a weak but

statistically significant negative correlation was observed between sleep duration and health indices (BMI, body mass, WC) such that less sleep was associated with increasingly adverse body composition. However, the observed correlation may have been moderated by the reported U-shaped relationship between sleep duration and health outcome (Buxton & Marcelli, 2010; Grandner, Hale, Moore, & Patel, 2010). The relative risk of CVD is considered higher among individuals reporting short duration sleep (<6 hours) and long duration sleep (>9 hours), however the definition of 'short' and 'long' sleepers differs between studies (Buxton & Marcelli, 2010; F. P. Cappuccio et al., 2010). Adults of working age should typically aim for 7-8 hours of sleep per night (RSPH, 2016). In the present study 65% of AS reported 7-8 hours of sleep per night, compared to FF (57%) and EC (50%), which may be the result of shift working. This difference, whilst interesting, requires further investigation to understand the contribution, if any, that differences in shift working practices may be making to reported sleep duration.

Sleep disturbance is widely reported as a precursor for a number of psychological conditions, including depressive symptoms (Wade, 2007) and sleep disruption is cited in 90% of depressive states (Germain & Kupfer, 2008). Indeed sleep disturbance has been shown to be as important as sleep duration when considering the risk of chronic disease in some populations (Chandola et al, 2010). In the present study, increased sleep duration, lower sleep disturbance and higher sleep quality were associated with more favourable reported psychological wellbeing irrespective of FRS role. However, FRS employees engaged in shift work tended to report a stronger positive association between sleep quality and wellbeing. These differences require further investigation yet may suggest that the importance of sleep for psychological health is greater among shift-workers than non-shift-workers and any alterations in sleep pattern has a more pronounced effect among shift-workers. Interestingly sleep duration had a weak negative correlation with age, irrespective of job role, which supports previous research that sleep duration alters with age (Klerman & Dijk, 2008). It is currently uncertain what causes age-related decreases in sleep propensity, however in the present study age-related changes in sleep disturbance, sleep quality and daytime sleepiness were not found. These results

may reflect the lower mean age (~43 years) in the present study compared to previous research (~ 60 years) (Klerman & Dijk, 2008).

Among large population-based studies, BMI is widely recognised to be a good indicator of health status and mortality risk (Berrington De Gonzales et al, 2010). However, at an individual level BMI is widely considered more useful in the presence of measured WC and/or adiposity (Carmienke et al, 2013; De Lorenzo et al, 2013) and to reduce confounding, weight history has been considered as a useful adjunct to mortality risk assessment (Adams et al, 2014; Stokes, 2014). It is agreed that both excess body fat and its location are important factors when considering chronic disease risk. The use of a combination of BMI and WC as an indirect assessment of body composition has recently proven useful in the firefighter population (Jitnarin et al, 2013). Somewhat expectedly in the present study individuals with higher SRH tended to have a lower BMI and WC, suggesting the respondents in this population are reasonably aware of their health status, particularly as it relates to body composition. Previous research has reported a poor understanding of BMI and associated health consequences among firefighters (Tsismenakis et al, 2012).

The role of physical activity in promoting physical (Anderson et al, 2014) and psychological wellbeing is well documented (De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006). Vigorous physical activity has been shown previously to moderate the stress response to a simulated emergency incident among a group of US firefighters. Favourable changes in stress reactivity were measured following a physical activity intervention program aimed at improving cardiorespiratory fitness (Throne et al, 2000). However, in the present study physical activity was not associated with psychological wellbeing irrespective of job role. Cardiorespiratory fitness was not measured in the present study and consequently self-reported physical activity may represent a poor surrogate for fitness in this population.

There is evidence of the detrimental affects of increased sitting time, which is independent of other lifestyle behaviours (Koster et al., 2012), although some studies suggest that sitting behaviour is particularly detrimental to health in the presence of inactivity (Åsvold et al., 2017; Henson et al, 2013) or perhaps inactivity coupled with obesity (Petersen et al., 2016). A recent position

statement has detailed the benefits of avoiding prolonged periods of sedentary activity that are typical of many occupational environments (Buckley et al., 2015). Furthermore, increased occupational sitting among highly active individuals has been linked to poorer psychological wellbeing (Puig-Ribera et al., 2015). Somewhat surprisingly in the present study, no significant relationships between time spent sitting and wellbeing were observed, irrespective of job role. However, significant negative associations between daily sitting time and physical activity in the present study, suggests that some physical activity was replaced with increased sitting. Among FF, Compared to AS and EC roles, increased physical activity and less daily sitting have been previously reported (chapter 1) which suggest that FF likely benefit from both being more physically active and less sedentary. Among FF only, a weak positive yet significant correlation was observed between sitting and BMI and WC, which may be a product of differences in occupational role. Firefighters, based on the requirements of the job, are likely to spend less time sitting compared to office-based FRS roles, meaning individuals in an operational role who still report higher sitting time will perhaps more likely be those with poorer health.

Self-reported health is widely regarded as a useful predictor of mortality, including chronic disease risk (Layes, Asada and Kephart, 2011) that is independent of socioeconomic and sociocultural factors (Jylha, 2009). In the present study, correlations between SRH, health characteristics and perceived wellbeing, suggesting the clinical value of a global health measure for assessment of both mind and body. Results of regression analysis support the use of SRH as an independent predictor of wellbeing irrespective of FRS role. Previous studies have found that perceptions of health vary between groups of different social, demographical and cultural status, which may weaken the predictive power of SRH (Jylha, 2009). In the present study, SRH was the only variable to correlate with both health characteristics and perceived wellbeing and would perhaps add predictive value to the use of standard stratification tools. The finding also supports the notion that the prognostic strength of self-rated health is found rather in its global value than by the sum of various health indices (Picard, Juster, & Sabiston, 2013). Recent research has examined the application of complex system dynamics to understand the interplay of differing variables in

determining health and wellbeing among populations (Rutter et al., 2017), with humans described as complex agents operating in and being operated by complex environments (Ma'ayan, 2017). A complex systems approach to health acknowledges the importance of interventions at multiple levels, including individual and population, such that health outcomes at the population level are greater than the sum of individual health behaviours (Rutter et al., 2017). It is therefore perhaps appropriate to consider the importance of SRH in the present study within the context of individual and population level complex systems (French et al., 2012). To acknowledge population health at the cost of individual level interventions or vice versa may present a false dichotomy such that interactions on health at multiple levels are overlooked (Sniehotta et al., 2017).

No clinically meaningful correlations were found between nutrition and wellbeing. This finding is perhaps more a reflection of the sensitivity of the survey protocol, given the previously reported lack of between group differences in mean scores for each dietary component (chapter 1). Although the overall reliability of the REAP protocol among a military population was acceptable, reliability for some dietary components was poor (Robinson et al., 2010). Administration of the REAP protocol using face to face interview would likely improve performance (Gans et al., 2006) and should be considered in future research among this population.

In conclusion, physical activity may have acted as a buffer against the adverse consequences of shift working. Irrespective of FRS role, sleep and SRH were found to be independent predictors of perceived psychological wellbeing and psychological distress. Further investigation should include objective markers of cardiometabolic disease risk in this population. Also, given the reported transient increase in cardiac risk among FF described elsewhere (SN Kales et al., 2007) the use of CVD risk stratification would likely prove beneficial for risk based lifestyle intervention.

CHAPTER 6

Study 3

Lifestyle and Perceived Wellbeing in Firefighters Classified as Low, Moderate and High Cardiovascular Disease Risk

6.1 Introduction

Responses to a health and lifestyle survey according to occupational role were described among a UK FRS population (chapter 4) and independent determinants of perceived psychological wellbeing reported (chapter 5). Given the previously reported increase in cardiac event associated with emergency response (Kales, Soteriades, Christoudias, & Christiani, 2003; Kales, Soteriades, Christophi, & Christiani, 2007), further investigation is warranted among the current FF population sample to determine the nature of CVD risk among operational firefighters and differences in lifestyle and perceived wellbeing between CVD risk groups.

Data from US firefighter populations show a high proportion (~50%) of on-duty deaths to be associated with cardiovascular disease (CVD) (Fahy, LeBlanc, & Molis, 2015). These deaths most typically occur during, or immediately after an emergency response, and are associated with enhanced physiological and psychological strain (Kales, Soteriades, Christoudias, & Christiani, 2003). In particular, a prior diagnosis of CVD, hypertension (Soteriades et al., 2003) and smoking (Glueck et al., 1996) are reported as independent predictors of on-duty cardiac event and are associated with a fourfold increase in risk (Geibe et al., 2008).

It is noteworthy that many of the firefighters that suffer a cardiac event, exhibit lifestyle behaviours and health characteristics associated with increased CVD risk (Smith et al., 2013). Firefighting is characterised by unpredictable periods of intense physical activity interspersed with prolonged periods of low physical activity such that a minimum role specific cardiorespiratory fitness standard is recommended for incumbents (R. Stevenson et al., 2017). It is surprising that few studies have reported physical activity behaviours in firefighter populations. A study among US firefighters found that >75% were not achieving recommended weekly physical activity levels for health (<150 minutes) and 37% measured a VO_2^{\max} of <42 ml/kg/min, under the minimum

acceptable standard for safe firefighting (Durand et al., 2011). Yet increased cardiorespiratory fitness and normal weight has been shown to be associated with a lower risk of the metabolic syndrome in firefighters (Baur, Christophi, & Kales, 2012). These findings suggest potential for reducing CVD risk factors among firefighters partaking in greater amounts of physical activity and increasing cardiorespiratory fitness.

However lifestyle interventions may need to consider perceptions of weight and fitness as firefighters may overestimate their level of fitness (Peate, Lundergan, & Johnson, 2002) and underestimate their weight (Tsismenakis, Jahnke, Baur, Christophi, & Kales, 2012). Also firefighters that underestimated their weight typically engaged in less physical activity than firefighters of normal weight (Tsismenakis et al., 2012). Misconceptions of weight and fitness may partly explain increasing prevalence of obesity among firefighters (Soteriades et al., 2005) and increasing risk of cardiac events associated with uncontrolled hypertension (Kales, Tsismenakis, Zhang, & Soteriades, 2009; Soteriades, Kales, Liarokapis, & Christiani, 2003). Although the relative risk of an on-duty cardiac event increases with age, sudden cardiac death among all US firefighters is associated with the same risk factors (e.g. hypertension, pre-existing CVD, smoking), suggesting a common aetiology, irrespective of age (Yang et al., 2013).

Among UK firefighter populations data also show a high proportion (~30%) of on-duty deaths are attributable to cardiac events (Figueiredo, 2006). Although the firefighting activities associated with such events is unclear, recent research with UK firefighters reported hemodynamic changes to a simulated fire suppression task that may predispose some firefighters to a transient increase in cardiac risk (Hunter et al., 2017). Consequently, it has been suggested that cardiovascular disease (CVD) risk stratification and lifestyle intervention may help mitigate the risk of cardiac events among firefighters (Kales et al., 2003; Lloyd-Jones, 2010; Smith et al., 2013; Soteriades, Smith, et al., 2011). Accordingly, having a better understanding of the psychological wellbeing associated with CVD risk stratification in this occupational group would be advantageous, not least given the psychological strain of emergency response (Murphy et al., 2002).

As mentioned earlier emergency response activities expose firefighters to both physiological and psychological stressors (Soteriades, Smith, et al., 2011), and research suggests exposure to traumatic events may increase the risk of psychological ill-being amongst firefighters (Chen et al., 2007). It is well established that depression is an independent risk factor for CVD (Vaccarino et al., 2008; Wulsin & Singal, 2003; Wulsin, Vaillant, & Wells, 1999). Furthermore increased sleep disturbance among firefighters is associated with psychological distress (De Barros, Fernandes Martins, Saitz, Rocha Bastos, & Mota Ronzani, 2013). Engaging in healthy lifestyle behaviours has been shown to positively influence psychological wellbeing (Lopresti et al., 2013). In particular, physical activity is understood to exhibit antidepressant effects such that fitter firefighters engaging in higher levels of physical activity are, on average, more emotionally resilient (Hamer, 2012; Throne et al., 2000).

Additionally, and considering the shift working requirements of emergency workers and the importance of sleep for cardiovascular health and psychological wellbeing (Vogel, Braungardt, Meyer, & Schneider, 2012), an understanding of sleep behaviour is warranted to further appreciate CVD risk among firefighters. To the best of our knowledge, only one published study has applied a CVD risk stratification model to a firefighter population and this work was among a small group (n=92) of US firefighters. In this study almost a third (29%) of firefighters were described as being at a high risk of developing CVD, compared to moderate risk (49%) and low (22%) risk (Smith et al., 2012). Yet, no details on physical activity engagement, psychological wellbeing or sleep behaviours were reported which may have provided further understanding of CVD risk.

To date, no study has examined CVD risk prevalence in UK firefighters or considered differences in relevant lifestyle behaviours or perceived psychological wellbeing between CVD risk groups. This study aims to compare self-reported physical activity and sleep behaviours, perceived wellbeing and self-rated health between firefighters according to predicted CVD risk groups. We hypothesised that on average individuals classed as being at a high or moderate risk of CVD development would engage in less physical activity and report higher psychological ill-being, lower psychological wellbeing, adverse

sleep behaviour and poorer self-rated health than individuals classed as being at a low risk of CVD development.

6.2 Methods

6.2.1 Participants

Participants for the study were all UK FRS operational firefighters (~50,000 firefighters). Internal communication networks were utilised nationally (Chief Fire Officers Association) and locally in each FRS to provide access to the health and lifestyle survey. Participants were given a full written description of the study on the first page of a survey before giving informed consent to participate. This study received approval from the University of Bath's Research Ethics Approval Committee for Health (REACH).

6.2.2 Study design

A health and lifestyle survey was made accessible online (via hyperlink) on fire station intranet systems and FRS websites for a period of six months (Jan-July 2013) to capture cross-sectional population data. Paper copies were also made available for when online access was not possible.

6.2.3 Health and Lifestyle Survey

A Health and Lifestyle Survey was compiled using a number of reliable and previously validated questionnaires. The survey was designed to collate self-report information on health characteristics [BMI, waist circumference (WC), waist to height ratio (WH_tR)], lifestyle behaviours (i.e., physical activity, nutrition, smoking, and alcohol), psychological wellbeing, sleep as well as other descriptive and demographic information. Questionnaires were selected based on their well-established use in occupational settings with good reliability and validity, and their being freely available. Where shortened versions of questionnaire protocol were available without markedly affecting validity and reliability, they were used to manage the overall length of the survey and attenuate participant burden.

The survey was composed of four sections; general information, lifestyle behaviour [physical activity (International Physical Activity Questionnaire; IPAQ; (Craig et al., 2003; Schembre & Deborah, 2011), nutrition (Rapid Eating Assessment for Patients; REAP) (Segal-Isaacson, Wylie-Rosett, & Gans, 2004), smoking (Cigarette Dependence Scale; CDS) (Jean-Francois Etter et al., 2003), alcohol (Alcohol Use Identification Test-C; AUDIT-C) (Reinert & Allen, 2007)], psychological wellbeing [depression, anxiety, stress (Depression, Anxiety, Stress Scale; DASS-21) (Henry & Crawford, 2005), mood (Positive and Negative Affect Scale; PANAS) (Watson et al., 1988), general life satisfaction (Satisfaction with Life Scale; SWLS) (Diener et al., 1985)], sleep (Pittsburgh Sleep Quality Index; PSQI) (Buysse et al., 1989) and sleepiness (Epworth Sleepiness Scale; ESS) (Johns, 1991)]. The health and lifestyle survey is discussed in more detail elsewhere (see General methods).

Internal reliability of the DAS-21 scale for the FF sample was calculated and found to have a very high level of reliability (Cronbach's $\alpha = 0.92, 0.79, 0.90$; for the depression, anxiety, and stress scales). Similarly, the internal reliability of the PANAS and SWLS were very high (Cronbach's $\alpha = 0.93, 0.88$; positive, negative affect and 0.91 ; SWLS).

6.2.4 Cardiovascular Disease Risk Classification

The American College of Sports Medicine (ACSM) CVD risk stratification tool (Pescatello et al., 2013) was applied to the survey data. Respondents were classed as either being at a low (<2 risk factors), moderate (≥ 2 risk factors), or high risk (pre-disclosed signs/symptoms of pulmonary, cardiovascular and/or metabolic disease) of developing atherosclerotic cardiovascular disease (CVD). Risk factors included age (men ≥ 45 yr; women ≥ 55 yr), cigarette smoking (current smoker or cessation ≤ 6 months), sedentary lifestyle (≤ 900 Met·mins·week⁻¹), obesity (BMI ≥ 30 kg·m⁻² or WC > 102 cm, men; > 88 cm, women), hypertension (pre-disclosed on health and lifestyle survey), dyslipidemia (pre-disclosed on health and lifestyle survey) and pre-diabetes (assumed if; age ≥ 45 yr and BMI ≥ 25 kg·m⁻² or age <45 yr and BMI ≥ 30 kg·m⁻²).

6.2.5 Statistical Analyses

All statistical analyses were completed using IBM SPSS Version 20 (IBM, New York, USA). Descriptive statistics (mean, standard deviation) are presented for the whole sample and separately for the three CVD risk groups (low; moderate; high). One-way analyses of variance (ANOVA) with bonferroni post hoc tests were conducted to detect group mean differences, and their location, between CVD risk groups for selected descriptive characteristics, perceived psychological wellbeing, sleep behaviours, physical activity and sedentary behaviour (daily time spent sitting).

Radar plots were used to illustrate differences in descriptive characteristics, physical activity, and reported wellbeing between ACSM risk groups in multiples of population standard deviation. The population sample mean is given as a reference. Radar plotting has been shown to be a useful method to convey meaning in multivariate data by using graphical presentation in health-related research (Saary, 2008).

Effect sizes (Hedges, 1981) were calculated to provide an assessment of the meaningfulness of any group differences whilst correcting for differences in the number of participants within each group. In this regard, an effect size of 0.2 is considered small, 0.5 moderate, and 0.8 or above large (Cohen, 1977). Statistical significance was set *a priori* at $p < 0.05$. All data are presented as mean (\pm SD) unless stated otherwise.

Internal reliability of the DAS-21 scale was calculated and found to have a high level of reliability (Cronbach's $\alpha = 0.92, 0.80, 0.90$; for the depression, anxiety, and stress scales). Similarly, the internal reliability of the SWLS and PANAS were very high (Cronbach's $\alpha = 0.93, 0.88$; positive, negative affect and 0.91; SWLS).

6.3 Results

6.3.1 Respondents

A health and lifestyle survey was completed by 2236 operational firefighters (2037 male, 199 female) from a workforce of ~50,000 (4.4% uptake). Respondent descriptive and health characteristics according to CVD risk

group [low: 561(25.1%); moderate: 1614(72.2%); high: 61(2.7%)] are included in Table 6.1.

6.3.2 Descriptive Characteristics

Descriptive characteristics among firefighters for the whole sample and individual CVD groups are displayed in Figure 6.1 and Table 6.1. Somewhat unexpectedly, the moderate and high risk CVD risk groups displayed a degree of homogeneity across body composition, age and FRS employment. However, respondents rated their health more poorly according to CVD risk group, such that the high CVD risk group rated their health the worst. Compared to low CVD respondents, moderate and high CVD risk group respondents were typically older [1.26 (1.0, 1.50); hedges g (95% CI) low: high] and had longer FRS employment [1.2 (0.94, 1.46); hedges g (95%) low: high] ($p < 0.05$). Compared to the low CVD risk group, body mass index [0.83 (0.57, 1.09); hedges g (95%) low: high], WC [0.86 (0.60, 1.12); hedges g (95%) for low vs. high] and WHtR [0.98 (0.72, 1.24); hedges g (95%) low: high] was highest in the high CVD risk group ($p < 0.05$).

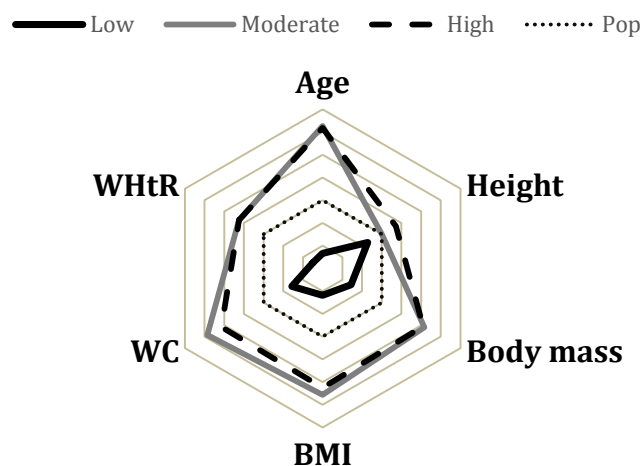


Figure 6.2 Radar plot of standardised z-scores for descriptive characteristics among firefighters grouped according to ACSM CVD risk stratification; low (solid black line); moderate (solid grey line); high (black dashed line); sample population mean (dotted line).

Table 6.1 Descriptive statistics for the sample and sub-samples (CVD risk group). Data are means (\pm SD) unless otherwise stated.

Participant characteristic/CVD risk group	All	CVD risk group		
		Low	Moderate	High
n(%)	2236	1303(58.3)	872(39)	61(2.7)
Age (y)	42(\pm 8)	38(\pm 7) ^{bc}	47(\pm 5) ^a	47(\pm 6) ^a
Body mass (kg)	85.3(\pm 12.8)	81.3(\pm 12.4) ^{bc}	90.9(\pm 11.0) ^a	90.7(\pm 11.9) ^a
Height (m)	1.79(\pm 0.07)	1.78(\pm 0.07)	1.79(\pm 0.06)	1.80(\pm 0.07)
BMI (Kg·m ⁻²)	26.7(\pm 3.3)	25.5(\pm 3.1) ^{bc}	28.4(\pm 2.9) ^a	28.1(\pm 3.2) ^a
Waist circumference (m)	0.87(\pm 0.08)	0.84(\pm 0.07) ^{bc}	0.90(\pm 0.07) ^a	0.90(\pm 0.08) ^a
Waist/height ratio	0.49(\pm 0.04)	0.47(\pm 0.03) ^{bc}	0.50(\pm 0.04) ^a	0.50(\pm 0.04) ^a
Self-rated health (1-4)*	1.87(\pm 0.6)	1.75(\pm 0.6) ^{bc}	2.02(\pm 0.6) ^{ac}	2.21(\pm 0.7) ^{ab}
Employment length (y)	18(\pm 8)	14(\pm 7) ^{bc}	23(\pm 7) ^a	23(\pm 8) ^a

Significantly different from ^aLow, ^bModerate, ^cHigh, $p < 0.05$. *A higher self-rated health score indicates poorer health.

6.3.3 Psychological Wellbeing

Perceived psychological wellbeing grouped according ACSM CVD risk stratification are presented in Figure 6.2 (below) and Table 6.2 (next page) Compared to low and moderate CVD risk groups, the highest reported depression, anxiety, stress was among high CVD risk respondents [0.54 (0.27, 0.80); 0.69 (0.43, 0.95); 0.54 (0.28, 0.81); hedges g (95% CI): depression, anxiety, stress scores for high vs. low group] and conversely, the lowest satisfaction with life score [0.21 (0.06, 0.36): hedges g (95% CI): for high vs. low group] ($p < 0.05$). From low to high CVD risk, positive mood decreased and negative mood increased, though these differences were not statistically significant.

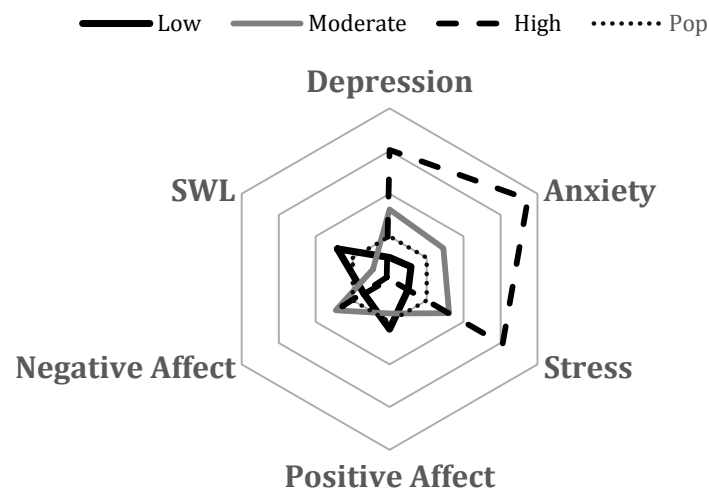


Figure 6.1 Radar plot of standardised z-scores for psychosocial construct and adverse mood among firefighters grouped according to ACSM CVD risk stratification; low (solid black line); moderate (solid grey line); high (black dashed line); sample population mean (dotted line).

Table 6.2 Perceived wellbeing and lifestyle according to CVD risk group. Data are means (\pm SD) unless otherwise stated.

Descriptive /CVD risk group	CVD risk group			
	All	Low	Moderate	High
n(%)	2236	1303(58.3)	872(39)	61(2.7)
<i>Psychosocial construct</i>				
Depression (0-21)*	3.17(\pm 3.9)	2.78(\pm 3.6) ^{bc}	3.66(\pm 4.2) ^a	4.75(\pm 4.2) ^a
Anxiety (0-21)*	1.55(\pm 2.0)	1.38(\pm 1.7) ^{bc}	1.73(\pm 2.2) ^a	2.65(\pm 2.8) ^a
Stress (0-21)*	3.94(\pm 3.9)	3.55(\pm 3.6) ^{bc}	4.41(\pm 4.1) ^a	5.53(\pm 4.3) ^a
Positive affect (0-25)*	16.6(\pm 4.9)	16.8(\pm 4.8)	16.4(\pm 5.1)	15.7(\pm 3.8)
Negative affect (0-25)*	6.55(\pm 2.3)	6.41(\pm 2.1) ^b	6.76(\pm 2.5) ^a	6.68(\pm 2.4)
Satisfaction with Life (0-35)*	18.6(\pm 7.1)	19.2(\pm 6.8) ^b	17.8(\pm 7.5) ^a	17.2(\pm 7.5)
<i>Sleep behaviour</i>				
Sleep (hrs.night ⁻¹)	6.74(\pm 1.1)	6.84(\pm 1.1) ^b	6.60(\pm 1.1) ^a	6.79(\pm 1.2)
Sleep disturbance (0-3)*	1.12(\pm 0.5)	1.08(\pm 0.5) ^{bc}	1.12(\pm 0.5) ^{ac}	1.39(\pm 0.6) ^{ab}
Sleep quality (0-3)*	1.11(\pm 0.7)	1.10(\pm 0.7)	1.14(\pm 0.7)	1.25(\pm 0.8)
Sleepiness (0-24)*	5.77(\pm 4.2)	5.54(\pm 4.0) ^b	6.07(\pm 4.5) ^a	6.41(\pm 4.7)
<i>Physical activity (MET.mins.week⁻¹)</i>				
Total	4882(\pm 3542)	5199(\pm 3516) ^b	4371(\pm 3517) ^a	4783(\pm 3710)
Vigorous	2222(\pm 2002)	2585(\pm 1986) ^b	1678(\pm 1885) ^a	2247(\pm 2246)
Moderate	1082(\pm 1318)	1148(\pm 1319) ^b	976(\pm 1299) ^a	1185(\pm 1477)
Walking	1102(\pm 1244)	1151(\pm 1263)	1035(\pm 1228)	1008(\pm 1014)
<i>Sedentary behaviour</i>				
Daily sitting time (mins.day ⁻¹)	302(\pm 163)	280(\pm 156) ^{bc}	332(\pm 167) ^a	338(\pm 167) ^a

Significantly different from ^aLow, ^bModerate, ^cHigh, $p < 0.05$. *A higher score indicates greater sleep disturbance, and/or poorer sleep quality, and/or higher daytime sleepiness, and/or higher depression, anxiety, stress and/or higher positive, negative mood, and/or life satisfaction.

6.3.4 Lifestyle

Lifestyle behaviours are presented according to CVD risk group in Table 6.2 (previous page) and Figure 6.3 (below) Compared to the moderate CVD risk group, the low CVD risk group reported longer sleep duration ($p<0.05$) and similarly the highest sleep disturbance was reported among the high CVD risk group [0.66 (0.40, 0.92); hedges g (95%): low vs. high] ($p<0.05$). Compared to the moderate CVD risk group only, the low CVD risk group reported higher total weekly physical activity with the greatest difference between reported vigorous physical activity levels [0.47 (0.38, 0.55); hedges g (95%): low vs. high]. The low CVD risk group spent the least time sitting [0.37 (0.08, 0.66); hedges g (95%): low vs. high] ($p<0.05$).

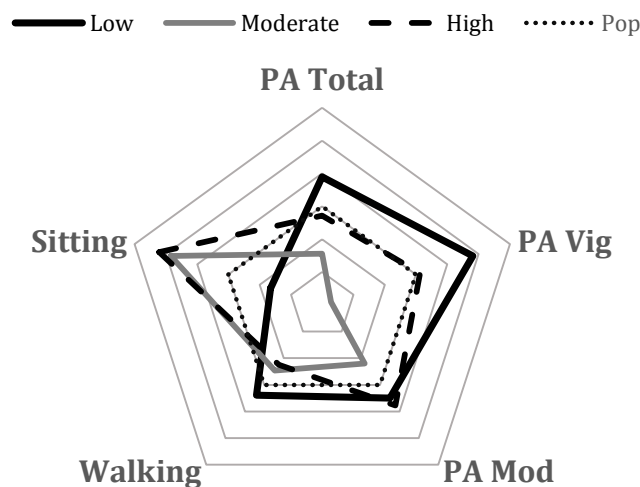


Figure 6.3 Radar plot of standardised z-scores for physical activity among firefighters grouped according to ACSM CVD risk stratification; low (solid black line); moderate (solid grey line); high (black dashed line); sample population mean (dotted line).

6.4 Discussion

Following completion of a health and lifestyle survey, operational firefighters (FF) were grouped according to their cardiovascular disease (CVD) risk. Respondents were classified as low (25.1%), moderate (72.2%) and high (2.7%) CVD risk. Respondents classed as being at a low risk of CVD, perceived their wellbeing more favourably (lower depression, anxiety, stress, negative mood and higher life satisfaction, positive mood) than moderate and high CVD risk groups. Furthermore low CVD risk respondents on average reported more night time sleep, of a higher quality and with fewer disturbances than higher CVD risk respondents. While these findings should not be interpreted as causal, they are supportive of the preponderance of research reporting multi-directional relationships between lifestyle factors associated with chronic disease, psychological wellbeing, and sleep behaviours (Atkinson & Davenne, 2007; Boehm & Kubzansky, 2012; Byrne & Byrne, 1993; Da Silva et al., 2012; Y. Liu, Ozodiegwu, Yu, Hess, & Bie, 2017; Lopresti et al., 2013).

The present study advances existing literature by applying an updated CVD risk stratification tool to a large cohort (n=2236) of operational firefighters and making between group comparisons for a range of lifestyle factors, perceived psychological wellbeing and sleep. The only previous study to apply a risk stratification tool to a firefighter population was based on a much smaller cohort (n=116) and did not consider potential moderating factors, such as lifestyle and psychological wellbeing (Smith et al., 2012). The present study did not have access to respondent family history of CVD, which can be incorporated in to the risk calculator. Previous research has identified that approximately 5% of operational firefighters have a family history of CVD which, if applied to the sample in the present study, may have increased the size of the moderate risk group, similar to the relative proportion previously reported (Smith et al., 2012). However, in these circumstances the high risk group would be unchanged, given the defining criteria for ACSM risk stratification (Pescatello et al., 2013).

The possible selection bias in this population, due to pre-employment selection criteria (healthy hired) and workplace medical screening (healthy survivor) was previously reported (Stevenson et al., 2017). Both factors are

known to contribute to a reported healthy worker effect (Choi, 2000). However, a reassessment of studies examining firefighting and CVD was completed in consideration of a healthy worker effect in firefighters and found evidence of an increased risk of CVD among firefighters, but it is still unclear if the increased risk is due to operational firefighting scenarios, non-occupational factors or both (Choi, 2000). The present study did not measure CVD prevalence directly, rather the prevalence of CVD risk factors, based on a self-report survey. CVD is a chronic disease that is associated with exposure to a number of genetic, environmental and behavioural risk factors that are often bi-directional and inherently difficult to interpret in isolation (Lloyd-Jones, 2010). Also, it is now recognised that a low CVD risk should not be interpreted as 'no risk', as any adverse risk factors may cause marked increases in absolute risk in the longer term (>10y) (Piepoli et al., 2016). The present study identified almost two thirds of firefighters as being at a moderate risk of CVD. This represented the largest risk group and therefore potentially a target for greatest improvement in absolute terms. An integrative health approach may be advantageous such that intervention targets at individual (identification of high CVD risk individuals) and population (identification of moderate CVD risk individuals) health levels are developed and encompass a broader notion of wellbeing (Witt et al., 2017). Integrative health is a developing area of health related research that considers individuals as complex agents within complex environments. This approach requires further investigation and is untested within Fire and Rescue Service occupational environments.

Psychological wellbeing impacts physiological wellbeing (Ryff, Singer, & Dienberg, 2004) and has measurable effects on CVD risk (Boehm & Kubzansky, 2012). The concept of wellbeing as a process rather than outcome has been proposed (Bhullar, Schutte, & Malouff, 2013). However, subjective wellbeing as an outcome is generally measured in the presence of positive affect, life satisfaction, and absence of negative affect (Lucas, Diener, & Suh, 1996). In the present study as with previous research, the three components of life satisfaction, presence of positive affect and absence of negative affect were used to assess subjective wellbeing (Ryff et al., 2004). On average subjective wellbeing was highest among the low CVD risk group, although the overall magnitude of

the differences between groups was modest. Previous analysis (chapter 2) did not identify any correlation between lifestyle and wellbeing, while reporting small and moderate correlations between body composition, self-rated health and wellbeing. In the present study, differences in body composition and self-rated health between the low CVD risk group, and both moderate and high groups may partly explain differences in wellbeing.

Recent research proposes that the protective effect of exercise on brain function may result from both central growth factors inducing structural change and by modification of peripheral risk factors including diabetes, CVD and hypertension that increase the risk of brain abnormalities (Cotman et al., 2007). Yet, more consistent differences in life satisfaction according to CVD group in the present study may indicate that respondents considered a number of health parameters in their assessment of life satisfaction (Diener et al., 1985).

The absence of positive psychological wellbeing does not necessarily determine the presence of psychological ill-being (Ryff, 1989). In support of previous research, the increase in psychological ill-being from low to moderate CVD group was not matched by lower psychological wellbeing and perhaps recognising these scales as distinct constructs.

We identified moderate effect sizes, reflecting differences in weekly vigorous physical activity and time spent sitting, between low and high CVD risk groups, suggesting that there is an opportunity to increase purposeful exercise more generally among high CVD risk group. This may be best achieved through a work-place and role-specific vigorous physical activity intervention (Siddall et al., 2016). Reduced vigorous activity among the high CVD group may have been influenced by medical conditions and an increased risk of cardiac event among this group (Fahy et al., 2015). Any intervention therefore, should be supported with appropriate prescreening and medical supervision, particularly given the previously reported increase of cardiac risk among inactive in . The firefighting role requires individuals to be able to cope with periods of vigorous physical exertion that are unpredictable and often emotionally challenging and therefore preparation is a prerequisite (Siddall et al., 2016). Encouragingly, physical activity interventions have been shown to both enhance physical fitness (Roberts et al., 2002) and lower stress reactivity (Throne et al., 2000) among firefighters. Yet,

such interventions are untested among older firefighters that are perhaps at a higher risk of cardiac event (Stefanos et al., 2003) and populated the high CVD risk group in the present study (~75% ≥45yrs and ~33% ≥50yrs).

Increasing daily movement through reduced sitting time should also be integrated into a physical activity strategy and would involve no transient increases in cardiac risk. Recent research reports increased mortality is associated with sedentary behaviour independent of moderate and vigorous activity (Koster et al., 2012). A targeted intervention aimed at reducing daily sitting time may represent a useful starting point for intervention among firefighters at a high CVD risk.

Sleep behaviours are widely reported as independent predictors of psychological wellbeing (Akerstedt, Kecklund, & Gillberg, 2007). More specifically, various components of sleep behaviours; sleep duration (Cappuccio et al., 2010), sleep quality (Jennings et al., 2007), sleep disturbance (Li, Zhang, Hou, & Tang, 2014), are recognised for different contributions to psychological wellbeing and CVD risk (F. Cappuccio et al., 2011). Sleep disturbance, described clinically as insomnia in chronic conditions, have been linked to CVD and cardiac events (Kanno et al., 2016; Li et al., 2014; Sofi et al., 2012) and increases in CVD risk associated with short sleep duration are additive among individuals with experiencing sleep disturbance (Chandola et al., 2010). However, the adverse health effects of sleep complaints are sensitive to the definition of sleep complaint adopted and it is unclear at times if the results are of clinical value (Phillips & Mannino, 2007). In the present study, the high CVD risk group reported the highest sleep disturbance of any group, which is of particular concern as previous research has reported a high prevalence of sleep disorders (>one third), in particular sleep apnea (~one quarter) among firefighters (Barger et al., 2015). Furthermore, among firefighters reporting sleep disorders there was a doubling of CVD and tripling of depression and anxiety prevalence (Barger et al., 2015). Given the safety critical nature of firefighting and potential for fatigue related task failure (Jay, Smith, Windler, Dorrian, & Ferguson, 2016), further investigations are warranted to understand the implications of sleep disturbance among firefighters at a high CVD risk.

In the current study, a risk stratification tool was applied to health and

lifestyle survey data from operational FF. Compared to low and moderate CVD risk respondents, high CVD risk respondents reported health characteristics associated with increased CVD risk, reported the highest adverse psychological wellbeing scores and somewhat expectedly therefore rated their health more poorly. Radar plots displayed graphically differences in health characteristics, lifestyle behaviours and psychological wellbeing between CVD risk group, such that respondents categorised as low CVD risk engaged in further healthy behaviours distinct from other CVD risk groups. Further investigation in a more controlled setting should investigate if sleep characteristics are different among firefighters identified as being at a high risk of developing CVD and if targeted interventions to improve sleep behaviour benefit psychological wellbeing among this group. Also, taking objective measurements of health and wellbeing in addition to a health and lifestyle survey would further our understanding of how relevant characteristics and markers are associated with increased chronic disease risk identified in this group.

CHAPTER 7

Study 4

Biomarkers of Cardiometabolic Health in Operational Firefighters Classified as Low and Moderate Cardiovascular Disease Risk

7.1 Introduction

Risk stratification is commonly used to identify individuals at increased risk of a cardiac event, those with pre-existing cardiovascular disease (CVD), and those who have elevated cardiometabolic component risks and are likely to develop CVD (Piepoli et al., 2016). CVD risk stratification can provide a summative assessment based on individual physical characteristics (e.g., age, body composition), lifestyle (e.g., physical activity, smoking) and health outcomes (e.g., medical history) (Kannel, D'Agostino, Sullivan, & Wilson, 2004; Lloyd-Jones, 2010). Further research suggests biomarkers of systemic inflammation may add diagnostic value to traditional CVD risk stratification (Albert, Glynn, & Ridker, 2003; Pearson et al., 2003; Ridker et al., 2008; Tofler et al., 2006) particularly among subgroups presenting as intermediate CVD risk (Lloyd-Jones, 2010). Differences in psychological wellbeing and lifestyle between FF grouped according to CVD risk has been reported previously (chapter 3). However, further investigation involving objective markers of health and inflammation would likely further understanding of CVD risk among FF.

Chronologic age is a heavily weighted variable in CVD risk prediction models. The mean age of UK operational firefighters has changed only marginally in recent times, yet 38% of operational firefighters are now more than 46 years of age; representing a 9% increase over 5 years from 29% in 2011 (Home Office, 2016). Interestingly, the Framingham risk stratification tool classes a 50 year old without major risk factor burden (i.e., Total cholesterol; HDL cholesterol; smoking; obesity; hypertension; diabetes) as being at a low lifetime (5% male; 8% female) risk of CVD development, yet the presence of a single major risk factor constitutes a substantial increase in risk burden (i.e., 10-fold for males; 5-fold for females) (Lloyd-Jones et al., 2006). The changing demographic of the UK Fire Service therefore represents a challenge for risk management, wherein the advancing age of the population may not necessarily reflect a true increase in

risk. Therefore, it may be useful to acquire a better understanding of more novel objective biomarkers when considering CVD risk among FF.

Inflammatory processes are widely considered to be instrumental in the development of CVD through the promotion of insulin resistance, diabetes, and obesity (Dandona, Aljada, & Bandyopadhyay, 2004). C-reactive protein (CRP) is a blood plasma, acute-phase protein released by the liver in response to inflammation following interleukin-6 (IL-6) secretion by macrophages and T cells and is characteristic of the chronic low grade inflammation associated with CVD risk that is independent of traditional risk factors (Oluleye, Folsom, Nambi, Lutsey, & Ballantyne, 2013). However in the presence of chronic low grade systemic inflammation, CRP and IL6 can be elevated independently of each other (Dixon, Hurst, Talbot, Tyrrell, & Thompson, 2009). The longer half-life of CRP (~19 hours), compared to IL-6 (~2 hours), supports the practical utility of CRP as a stable biomarker of systemic inflammation related to chronic disease (Ridker, 2003, 2016). Also CRP is a receptor at the end of the inflammatory cascade and the relative stability of this cytokine receptors supports its utility clinical biomarker of inflammation (Cesari et al., 2003). Clinical intervention has been investigated in large population trials for various concentrations of CRP, including the use of $\geq 2 \text{ mg}\cdot\text{L}^{-1}$ as chronic low grade inflammation (Yang et al., 2013) and/or low ($<1 \text{ mg}\cdot\text{L}^{-1}$), moderate ($\geq 1 \leq 3 \text{ mg}\cdot\text{L}^{-1}$), high ($>3 \text{ mg}\cdot\text{L}^{-1}$) CVD risk cut offs (Ridker, 2003) with both methods adding improving CVD risk stratification. Recent evidence suggests that inclusion of CRP ($\geq 2 \text{ mg}\cdot\text{L}^{-1}$) among populations at a moderate risk of CVD, may prevent an additional coronary event per approximately 400 assessments (Emerging Risk Factors Collaboration, 2012). However, the addition of CRP and Tumor Necrosis Factor (TNF α) to CVD risk stratification has been shown to improve prediction of a coronary event by 11% (Woodward, Welsh, Rumley, Tunstall-Pedoe, & Lowe, 2010).

Although increased habitual physical activity is associated with a lower risk of developing CVD (Aadahl et al., 2009), vigorous physical activity participation is associated with a transient increase in cardiac event risk (Mittleman et al., 1993), particularly among individuals reporting lower physical activity levels (Willich et al., 1993) as well as individuals with pre-existing CVD

(Pelliccia et al., 2006). Within their role, operational firefighters experience unpredictable periods of strenuous physical activity during emergency response, potentially exposing some individuals with underlying CVD to increasing risk of a cardiac event (Soteriades, Smith, Tsismenakis, Baur, & Kales, 2011; Stefanos et al., 2003; Yang et al., 2013). However, data from US firefighters suggests that although the nature of emergency response activities remains unpredictable, firefighters experiencing cardiac events display health characteristics (e.g. obesity, hypertension, prediagnosed CVD) and modifiable lifestyle behaviours (e.g. smoking, low cardiorespiratory fitness) associated with CVD (Soteriades, Targino, et al., 2011; Soteriades, Smith, et al., 2011; Stefanos et al., 2003)

To of our knowledge, the only published study to consider objective biomarkers of CVD risk in a firefighter population reported higher concentrations of inflammatory markers in obese compared to non-obese individuals (Smith et al., 2012). Yet in this work, no comparison was made between CVD risk group and any potential differences in lifestyle behaviours, which may contribute to explaining the reported differences. Moreover, other studies have investigated lipid profiles and health outcome among US firefighter populations and mostly found adverse lipid profiles to be linked with adiposity (Byczek et al., 2004; BongKyoo Choi et al., 2016). However, commonly used BMI classification does not recognise individuals with higher muscle mass or with higher abdominal visceral fat stores and has been shown to overestimate overweight and obesity among a firefighter population when compared to waist circumference (BongKyoo Choi et al., 2016). Waist circumference (WC) and more recently waist-to-height ratio (WtHR) (Swainson, Batterham, Tsakirides, Rutherford, & Hind, 2017) have been proposed as more sensitive measures of cardiometabolic risk (Czernichow, Kengne, Stamatakis, Hamer, & Batty, 2011), perhaps reflecting their sensitivity to abdominal fat stores and elevated risk of insulin resistance sometimes described as the metabolic syndrome (Després, 2012). Among a firefighter population, systemic inflammation has been reported to be higher among BMI defined obese compared to non-obese. Such data suggest that BMI is a useful adjunct for disease risk in this group (Choi et al., 2016), supporting the relation between fat mass and chronic inflammation

(Festa et al., 2001). Given previous investigations reporting misclassification risk with the use of BMI in this occupational firefighter population (Choi et al., 2016) coupled with the importance of body fat distribution for disease risk, it is proposed that the use of waist circumference (WC), waist to height ratio (WtHR), body fat percentage (BF%), and fat mass (FM%) combined with inflammatory markers would likely add further understanding of CVD risk among firefighters.

The primary purpose of this study was to compare systemic concentrations of inflammation biomarkers and lipids between operational firefighters classified as low (LOW) and moderate (MOD) risk of cardiovascular disease. Separating respondents into quartiles according to adiposity (BF%, FM) and making group comparisons of inflammatory marker concentrations, would likely provide further understanding of the association between excess body mass and inflammation among firefighters.

7.2 Methods

7.2.1 Participants

This study was approved by the University of Bath's Research Ethics Approval Committee for Health (REACH). Participants were current operational firefighters from across the UK. All participants had previously completed an online health and lifestyle survey (Appendix A) and given written consent to be contacted regarding involvement in future research. All participants received a detailed verbal and written brief prior to data collection. To this end, data were primarily collected at the participant's place of work (i.e., home fire station), yet some were collected from the Fire Service College, Moreton on the Marsh.

7.2.2 Study design

At the end of the health and lifestyle survey (pg. 20 of Appendix A) participants had the option of informed consent for future research. A population sample was selected from willing participants reporting as operational firefighters (FF) such that both northern and southern FRS UK regions represented the sample. Following organisational consent, discussions were

completed with all personnel at each participating fire station, such that all participants were well informed of the study protocol (Appendix B) and consent given (Appendix C).

7.2.3 Anthropometrics

A standardised protocol was used wherein height was measured using a clinical stadiometer (Seca 216; Leicester UK) and body mass was assessed using calibrated weighing scales (Seca; Hamburg Germany). During data collection, firefighters wore light clothing and no shoes. Body fat percentage was predicted using a bioelectrical impedance method (Bodystat 1500, Isle of Man).

7.2.4 Cardiovascular disease risk stratification

The American College of Sports Medicine (ACSM) CVD risk stratification tool was used to group respondents according to low and moderate CVD risk. A small number of respondents (three) classified as high CVD were excluded from the analysis because of the low number. The ACSM CVD risk stratification tool (Pescatello et al., 2013) has been described in detail previously (Chapter 3). Respondents were classed as either being at a low (<2 risk factors), moderate (≥ 2 risk factors).

7.2.5 Blood sampling

A fasted blood sample was taken from 180 operational firefighters following completion of a health and lifestyle survey that was described previously (chapter 1). Blood samples were obtained by venipuncture from an antecubital vein using a needle and vacutainer system (BD Diagnostics, Becton, UK) from participants upon waking (0700-0800 hours) using plain untreated tubes (6 mL) and tubes (6 mL) containing ethylenediaminetetraacetic acid EDTA. Serum and plasma were separated into ependorf tubes following centrifugation on-site and stored at -80°C .

Commercially available enzyme immunoassays (R&D Systems Inc., Abingdon, UK) were used to measure serum concentrations of IL-6 (Sensitivity $0.04 \text{ pg}\cdot\text{mL}^{-1}$; CV 7.4%) and TNF α (Sensitivity $0.191 \text{ pg}\cdot\text{mL}^{-1}$; CV 8.7%). Plasma concentrations of CRP, total cholesterol (TC) and concentrations of high density

lipoprotein (HDL-C), triglycerides (TG) and non-esterified fatty acids (NEFA) were measured using an automated spectrophotometer (Daytona, Randox Laboratories, Northern Ireland). The Friedewald equation was used to predict low density lipoprotein LDL for concentrations in mmol.L⁻¹ shown below:

$$LDL \approx C - HDL - 0.45T$$

Where C is total cholesterol and TG is concentration of triglycerides. For triglyceride levels above 4.5 mmol.L⁻¹ the Friedwald equation loses accuracy, so data were not included in these instances.

7.2.6 Data analysis

Statistical analyses were completed using SPSS 21.0 for Mac (IBM, New York, US). Normality tests were conducted (Shapiro Wilk), with visual inspection of histogram plots for all blood sample data. Independent samples t-tests were conducted to test for significant differences when data were normally distributed and independent samples Mann-Whitney U tests when data were non-normally distributed. Data analysed by independent t-test are presented as mean \pm SD. Data analysed by Mann Whitney U test are presented as median (inter-quartile range).

Results are illustrated as radar plots using multiples of the population standard deviation. Radar plotting has been reported as an effective method to convey meaning in multivariate data using graphical presentation in health-related research (Saary, 2008). Respondents were then separated into quartiles of fat mass and body fat percentage and comparisons made for mean values of inflammatory markers between the lowest and highest quartiles.

Effect sizes (Hedges, 1981) were calculated using the Hedge's G (*g*) pooled standard deviation method to provide an assessment of the meaningfulness of any group differences whilst correcting for sample size. In this regard, an effect size of 0.2 is considered small, 0.5 moderate, and 0.8 or above large (Cohen, 1977). Statistical significance was set *a priori* at $p < 0.05$. All data are presented as mean (\pm SD) unless stated otherwise.

7.3 Results

7.3.1 Participants

Descriptive characteristics for the sample and separated by CVD risk group are presented in Table. 7.1 Most respondents rated their health as [n (%)] excellent or good [162 (90%)], with the remaining as fair or poor [18(10%)]. Compared to moderate CVD risk respondents, low CVD risk respondents were typically younger ($p < .05$; $g = 1.19$), with subsequently shorter FRS employment ($p < .05$; $g = 0.93$). Moderate CVD risk respondents typically had a higher BMI ($p < .05$; $g = 1.06$), BF% ($p < .05$; $g = 0.52$), and FM ($p < .05$; $g = 0.73$) than those in the low CVD risk group.

Table 7.4 Descriptive statistics for a cohort group of firefighter respondents to the health and lifestyle survey; presented for the sample and according to ACSM low and moderate risk stratification. Data are means (\pm SD) unless otherwise stated.

Descriptive n(%)	All 180	CVD risk group ¹		Effect sizes Hedges <i>g</i> (90% CI)
		Low 122(68)	Moderate 55(31)	
Age (y)	41 (\pm 7)	38 (\pm 7)	46 (\pm 6) ^a	1.19 (0.85,1.53)
Body mass (kg)	83 (\pm 12)	81 (\pm 12)	88 (\pm 9) ^a	0.62 (0.95, 0.30)
Height (m)	1.78 (\pm 0.07)	1.78 (\pm 0.07)	1.78 (\pm 0.06)	NS
BMI (kg.m ²)	26 (\pm 3)	25 (\pm 3.1)	28 (\pm 2.1) ^a	1.06 (1.39, 0.72)
WC ² (m)	0.85 (\pm 0.07)	0.83 (\pm 0.07)	0.87 (\pm 0.05) ^a	0.62 (0.94, 0.29)
WHtR ³	0.48 (\pm 0.03)	0.47 (\pm 0.03)	0.49 (\pm 0.03) ^a	0.67 (0.99, 0.34)
Body fat (%)	21.6 (\pm 5.0)	20.8 (\pm 5.2)	23.3 (\pm 3.8) ^a	0.52 (0.84, 0.19)
Fat mass (Kg)	18.2 (\pm 5.7)	17.0 (\pm 5.7)	21 (\pm 4.9) ^a	0.73 (1.06, 0.40)
SRH ⁴ (score)	1.91(\pm 0.5)	1.85 (\pm 0.6)	2.01 (\pm 0.6)	0.27 (0.58, 0.05)
Employment (y)	16 (\pm 8)	14 (\pm 6.7)	21 (\pm 9.0) ^a	0.94 (1.26, 0.60)

Significantly different from ^aLow, $p < 0.05$. ¹three respondents classified as being at a high risk of CVD were excluded.

² Waist circumference (WC). ³Waist to height ratio (WHtR). ⁴Self-rated health (SRH) score (1 to 4); 1 is excellent and 4 is poor.

7.3.2 Cardiovascular disease risk group comparison

7.3.2.1 Physical activity

Reported physical activity levels for the sample and by CVD risk group are presented in Table 7.2 (next page) Compared to moderate CVD risk respondents, low CVD risk respondents reported less daily sitting time ($p < .05$; $g = 0.57$). Compared to the moderate CVD risk group, PA participation was significantly ($p < 0.05$) higher for the low group across all exercise intensities. The largest effect size ($r = 0.24$) was for vigorous PA [median (IQR)] which was significantly higher in the low CVD risk group [2160(2400) MET.mins.week⁻¹], compared to the moderate CVD risk group [1440(2480) MET.mins.week⁻¹] ($p < 0.05$).

Table 7.2 Physical activity and sedentary behaviours for the firefighter sample and according to CVD risk group. Data are means (\pm SD) unless otherwise stated.

Descriptive /CVD risk group	Measure of Central Tendency	CVD risk group ¹		Effect sizes; significance
		Low	Moderate	
n(%)	180	122(68)	55(31)	
<i>Physical activity</i> ² (MET.mins.week ⁻¹)				<i>r</i> value; sig
Total	Median (IQR)	4524(5325)	3672(4053) ^a	0.15; p<0.05
Vigorous	Median (IQR)	2160(2400)	1440(2480) ^a	0.24; p<0.05
Moderate	Median (IQR)	960(1920)	640(1920) ^a	0.16; p<0.05
Walking	Median (IQR)	792(1980)	990(1518)	0.05; NS
<i>Sedentary behaviour</i>				Hedges <i>g</i> (90% CI); sig
Daily sitting time (mins.day ⁻¹)	Mean (\pm SD)	205(\pm 99)	270(\pm 140) ^a	0.57 (0.25, 0.90); p<0.05

Significantly different from ^aLow, p<0.05. ¹Three respondents, classed as high CVD risk were not included. ²It should be noted that nine respondents reported ≤ 900 MET.mins.week⁻¹ of which seven were included in the moderate CVD risk group, including five with ≥ 3 risk factors.

7.3.2.2 Body composition and blood analysis

Mean values for body composition, blood lipids, and inflammatory biomarkers for the sample and CVD risk group (low: moderate) are presented in Table 7.3 (next page) and graphically in Figure 7.1 and Figure 7.2 (Page 145). Compared to the moderate CVD risk group, the low CVD risk group exhibited a healthier blood lipid profile; lower TC ($p < 0.05$; $g = 0.52$), LDL-C ($p < 0.05$; $g = 0.56$) and higher HDL-C ($p < 0.05$; $g = 0.47$). Inflammatory biomarker levels tended to be higher in the moderate group, compared to the low CVD risk group, yet a clinically meaningful difference was only measured for TNF α ($p < 0.01$; $g = 0.42$).

It should be noted that median concentration of CRP in healthy young volunteers is $0.8 \text{ mg}\cdot\text{L}^{-1}$ and the 90th centile has been reported at $3 \text{ mg}\cdot\text{L}^{-1}$ (Pepys & Hirschfield, 2003), and used as a threshold for CVD risk (Pearson et al., 2003). However, among a middle-aged US general population sample the 90th centile was $6.6 \text{ mg}\cdot\text{L}^{-1}$ (Ridker, Rifai, & Rose, 2003). In the present sample, a median concentration of $0.72 \text{ mg}\cdot\text{L}^{-1}$ and 90th centile of $2.87 \text{ mg}\cdot\text{L}^{-1}$ compares this sample favourably with healthy, young populations and may have confounded the measurement of differences in inflammatory marker concentrations between CVD risk groups.

Pearson correlation analysis between inflammatory markers and lipids (Appendix G) reported a moderately strong positive association between CRP and IL-6 ($r = 0.51$; $p < 0.01$) but not TNF α . TNF α correlated with various lipid sub-fractions, and in particular a moderate negative association with HDL-C ($r = -0.35$; $p < 0.01$).

Table 7.5 Markers of inflammation and lipids for a cohort group of firefighter respondents to the health and lifestyle survey; presented for the sample and according to ACSM low and moderate risk stratification. Data are means (\pm SD) unless otherwise stated.

Descriptive n (%)	Measure of	CVD risk group ¹		Effect sizes; significance
	Central Tendency	Low	Moderate	
	180	122(68)	55(31)	
<i>Inflammatory biomarkers</i>				
				<i>r</i> value; sig
CRP (mg·L ⁻¹)	Median (IQR)	0.67 (1.09)	0.91 (0.79)	0.10; NS
IL-6 (pg·mL ⁻¹)	Median (IQR)	0.80 (0.79)	0.77 (0.56)	0.003; NS
TNFα (pg·mL ⁻¹)	Median (IQR)	0.60 (0.80)	1.00 (0.87) ^a	0.15; p<0.05
<i>Lipids</i>				
TG (mmol·L ⁻¹)	Median (IQR)	1.03 (0.66)	1.25 (0.99)	0.15; p=0.52
NEFA(mmol·L ⁻¹)	Median (IQR)	0.34 (0.49)	0.36 (0.42)	0.03; NS
Hedges <i>g</i> (90% CI); sig				
TC (mmol·L ⁻¹)	Mean (±SD)	5.04 (±0.78)	5.49 (±1.0) ^a	0.52 (0.85, 0.20); p<0.05
HDL-C (mmol·L ⁻¹)	Mean (±SD)	1.29 (±0.30)	1.15 (±0.26) ^a	0.48 (0.16, 0.81); p<0.05
LDL-C (mmol·L ⁻¹)	Mean (±SD)	3.19 (±0.78)	3.62 (±0.72) ^a	0.56 (0.24, 0.89); p<0.05
TC/HDL-C	Mean (±SD)	4.21 (±1.1)	4.65 (±1.0) ^a	0.41 (0.09, 0.73); p<0.05
LDL-C/HDL-C	Mean (±SD)	2.60 (±0.91)	3.28 (±0.88) ^a	0.75 (0.42, 1.08); p<0.05

Significantly different from ^aLow, p<0.05. ¹three respondents classified as being at a high risk of CVD were excluded.

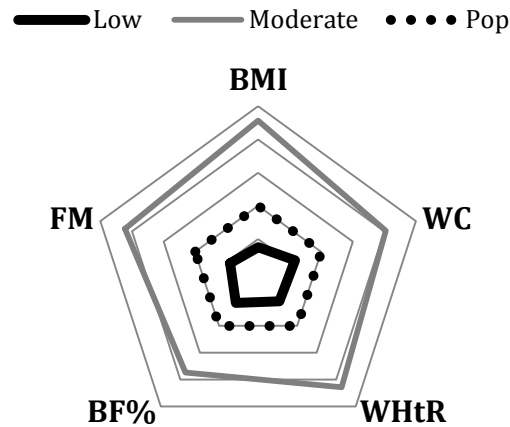


Figure 7.5 Radar plot of standardised z-scores for selected measures of body composition [body mass index (BMI): waist circumference (WC): waist to height ratio (WHtR): body fat percentage (BF%): fat mass (FM). Scores are grouped according to ACSM CVD risk stratification; low (solid black line): moderate (solid grey line): sample population (dotted line).

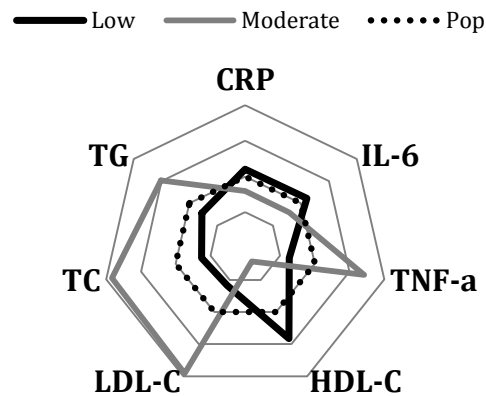


Figure 7.6 Radar plot of standardised z-scores for selected blood lipids and inflammatory biomarkers [C-reactive protein (CRP): interleukin 6 (IL-6): tumor necrosis factor- α (TNF α)]. Scores are grouped according to ACSM CVD risk stratification; low (solid black line): moderate (solid grey line): sample population (dotted line).

7.3.3 Body fat percentage and fat mass quartiles

Pearson correlations showed body fat percent (BF%) and fat mass (FM) to be significantly associated with inflammatory markers and lipids (Appendix. H). To further explore this relationship, both body composition variables (BF%, FM) were separated into quartiles and mean values are presented for CRP, IL-6, TNF α (Figure 7.3) and TC, HDL-C, TG (Figure 7.4) (next page). Compared to the highest BF% ($\geq 24.5\%$) and FM ($\geq 21.5\text{kg}$) quartiles, individuals in the lowest BF% ($< 18.5\%$) and FM ($< 13.8\text{kg}$) quartiles were typically younger ($p < 0.01$; $g = 0.82$ & 0.71 for BF%, FM) and with shorter FRS employment ($p < 0.01$; $g = 0.85$ for both BF% and FM).

Compared to the lowest body fat quartile, individuals in the highest body fat quartile typically displayed higher concentrations of inflammatory biomarkers, higher TC, lower HDL-C and higher TG. However, statistical significance and a meaningful effect size difference were measured only for TC ($p < 0.05$; $g = 0.44$) and IL-6 ($p < 0.01$; $g = 0.57$).

Compared to the lowest fat mass quartile, individuals in the highest fat mass quartile typically displayed higher concentrations of inflammatory biomarkers; higher CRP ($p < 0.05$; $g = 0.69$), IL-6 ($p < 0.01$; $g = 0.65$) and a less healthy lipid profile; higher TC ($p < 0.05$; $g = 0.46$), lower HDL-C ($p < 0.01$; $g = 0.69$), higher TG ($p < 0.05$; $g = 0.48$).

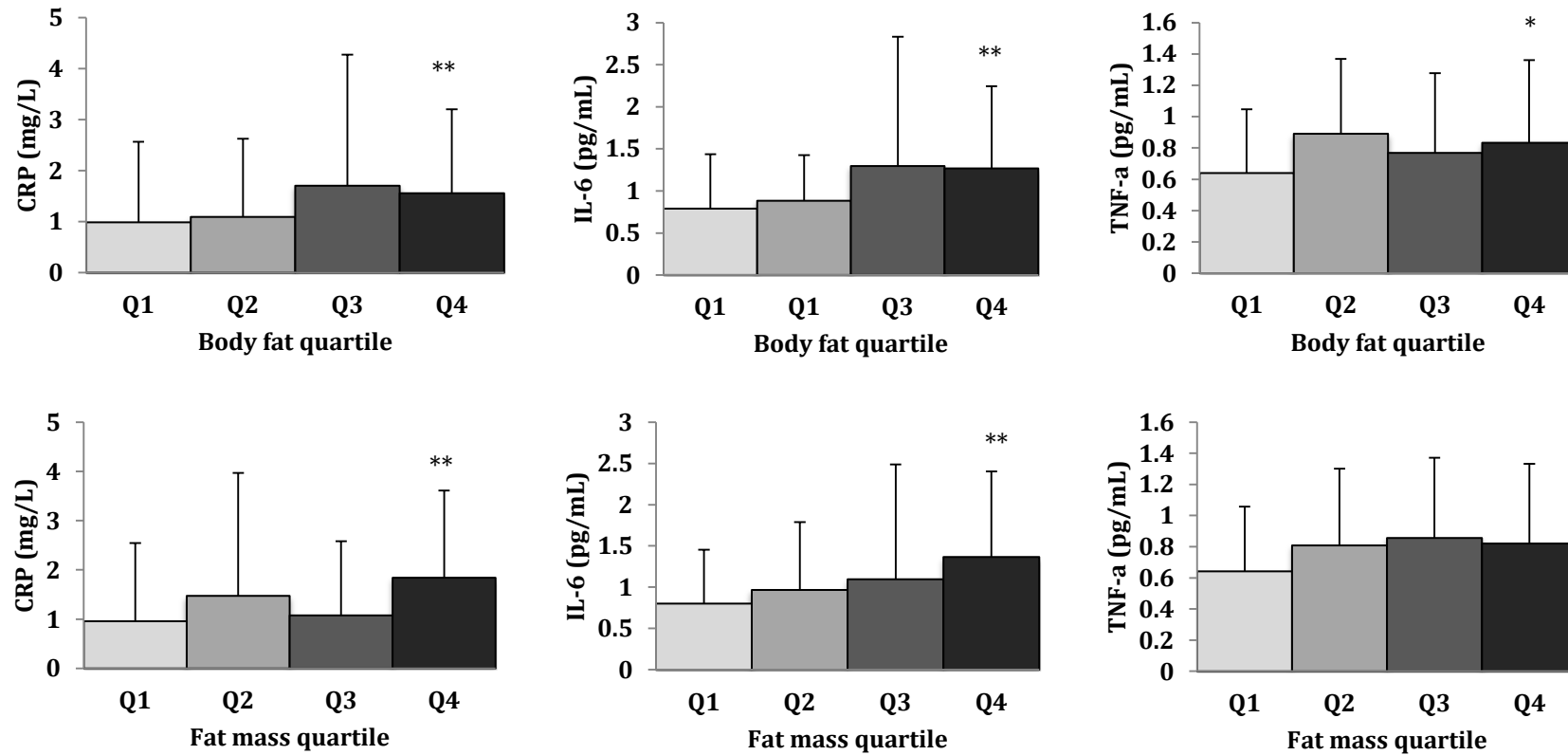


Figure 7.7 Mean values of CRP, IL-6, TNF α grouped according to quartiles of body fat (%) (Q1: <18.5; Q2: 18.5<21.15; Q3: 21.15<24.5; Q4: \geq 24.5) and fat mass (kg) (Q1: <13.8; Q2: 13.8<17.7; Q3: 17.7<21.5; Q4: \geq 21.5). Q4 statistically different to Q1 at the *P<0.05 and **P<0.01 level.

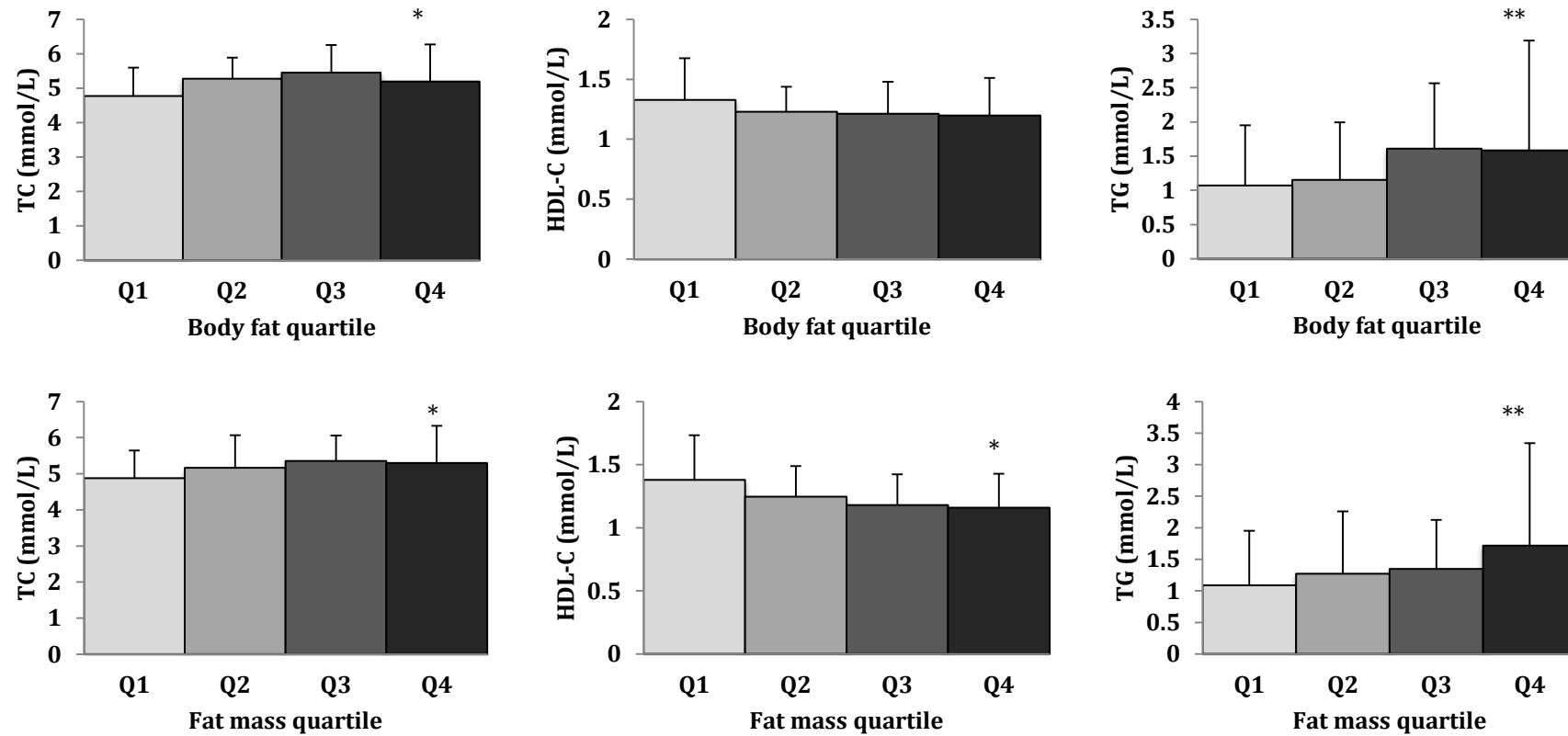


Figure 7.8 Mean values of TC, HDL-C, TG grouped according to quartiles of body fat (%) (Q1: <18.5; Q2: 18.5<21.15; Q3: 21.15<24.5; Q4: ≥24.5) and fat mass (kg) (Q1: <13.8; Q2: 13.8<17.7; Q3: 17.7<21.5; Q4: ≥21.5). Q4 statistically different to Q1 at the *P<0.05 and **P<0.01 level.

7.4 Discussion

A sub-sample of respondents to a health and lifestyle survey volunteered to provide blood samples for monitoring of lipids and inflammatory markers associated with CVD risk. Compared to individuals described as moderate CVD risk, individuals classed as being at a low risk of CVD had a healthier lipid profile (moderate effect size difference) and lower circulating inflammatory markers (moderate effect size for TNF- α only). Furthermore, comparison of individuals into lower and upper FM quartiles found moderate to large effect size differences in inflammatory marker concentrations (CRP, IL-6) and circulating lipids (TC, HDL-C, TG), coupled with large effect size differences in age and years of FRS employment. It is interesting to note that although differences in circulating inflammatory biomarkers and lipids were more apparent between groups by body composition (FM) rather than CVD risk stratification, both methods identified healthy lifestyle behaviours and characteristics. For longer-term employee CVD risk management, healthy lifestyle promotion strategies may be most effective if directed at early career individuals and aimed at preventing incremental increases in adiposity and adverse lipid profile in the short term, which may help reduce increases in markers of systemic inflammation in the longer term.

In a group of UK operational firefighters, we report differences in circulating biomarkers and lipid markers in individuals stratified by CVD risk and body composition. To our knowledge, inflammation has been measured once in the extant literature within a group of US firefighters (Smith *et al.*, 2012) where somewhat in agreement with the present study significant differences in circulating CRP concentrations were reported according to BMI classification. However, Smith *et al.* (2012) did not make CVD risk group comparisons on inflammatory markers and the use of BMI as a measure of adiposity has been shown to have diagnostic limitations previously in firefighter populations. In the present study, percentage body fat and fat mass correlated more closely than BMI with changes in inflammatory markers and may add diagnostic value to CVD risk classification in this population. Furthermore, CRP and IL-6 reported a moderate positive correlation ($r = 0.51$, $p < 0.01$) with each other but not with any

lipids, giving further confidence that these inflammatory markers may add diagnostic value.

Despite advancing the literature in a number of ways, the present study has a number of limitations. First, the population sampled relied on a volunteer cohort of respondents to a health and lifestyle survey. This may have resulted in participant bias such that more healthy individuals were more likely to participate in a study involving objective markers of health not least if job suitability depended to some extent on health and fitness criteria. Comparison of results between the complete firefighter sample (Chapter 3) and the blood sample cohort may support this possibility. Differences in lifestyle behaviours both between the samples and among CVD risk groups were such that the blood sample group typically had less excess body mass, higher physical activity amount, less daily sitting time, and rated their health more highly with a higher proportion rating their health as excellent or good (90% in blood sample group versus 58% in complete FF sample). Higher physical activity levels in the blood sample group may have resulted in cardiometabolic adaptations that confounded analysis of inflammatory marker concentrations by CVD risk group.

Second, blood samples were obtained in the workplace (typically the fire station) setting and included participants that were both 'going off duty' and 'coming on duty'. Most notably between these two groups was the possibility that the 'going off duty' group may have experienced sleep disturbance due to emergency response during their night shift. The physical work environment is reported as influential in sleep behaviour (Linton et al., 2015) including higher sleep disturbance among shift workers at the start of their shift work, by comparison to workers finishing shift work (Åkerstedt, Nordin, Alfredsson, Westerholm, & Kecklund, 2010). Sleep disturbance is a known mediator of inflammatory cytokines (Mullington, Haack, Toth, Serrador, & Meier-ewert, 2009) including IL-6 (Shearer et al., 2001), CRP (Meier-ewert et al., 2004) and TNF- α (Shearer et al., 2001). Differences in sleep status between individuals at differing points in their respective shift patterns may have therefore influenced concentrations of inflammatory biomarkers. However it is anticipated that requiring participants were fasted, avoidance of strenuous exercise, and having consistent sampling times (07.00-09.00 hours) reduced confounding. Also, by

comparison to IL-6, CRP has a longer half-life (Vigushin, Pepys, & Hawkins, 1993) and is without diurnal rhythm (Meier-ewert et al., 2001).

Third, body fat analysis using hydrodensitometry or DXA analysis was not feasible in the present study for methodological, practical, and financial reasons. This said, the use of bioelectrical impedance analysis (BIA) for body composition measurement is a valid and reliable method (Bolanowski & Nilsson, 2001; Jackson, Pollock, Graves, & Mahar, 1988) and there are data reporting error among obese individuals (Duren et al., 2008). In the present study the obese group (7.2%) as identified by BMI was the smallest group, which would, reduce any error effect. Also, serum CRP concentrations correlated similarly with all body composition analysis measures, perhaps further substantiating identification of BF(%) and FM by BIA in this population.

Lipid profiles have been reported previously among firefighter populations using differing methods making exact comparisons difficult. Choi *et al* (2016) used BMI, WC, and BF(%) to make CVD risk factor comparisons among 365 US firefighters, reporting poorer lipid profiles (higher TC, LDL-C, TG and lower HDL-C) with increasing adiposity across all three body composition measures. However, Geibe *et al* (2008) reported that serum cholesterol was not a significant predictor of on-duty CVD event, although noted the limitation of insufficient data for a complete lipid panel assessment. Interestingly, Geibe *et al* (2008) found the proportion of BMI defined overweight and/or obesity to be similar among fatalities and survivors, perhaps suggesting that some cardiac event survivors had been removed from operational duties. Soteriades *et al* (2005) reported a higher prevalence of low HDL-C among obese, compared to non-obese firefighters, although lipid profiles were broadly similar between groups. However samples were non-fasted making comparisons with the present work difficult.

In the present study, HDL-C concentrations were highest among the low CVD risk group in agreement with the widely reported cardio protective properties of HDL-C (Barter et al., 2007; Cockerill, Rye, Gamble, Vadas, & Barter, 1995; Fernandez & Webb, 2008). Also HDL-C concentration was negatively associated with CRP and TNF- α , which is in agreement with previous studies reporting the inhibiting role of HDL-C on the pro-inflammatory effect of

circulating CRP (Wadham et al., 2004). Low levels of CRP are naturally expressed in plasma and HDL-C is thought to protect the vasculature by inhibiting the expression of cytokine-induced inflammatory adhesion molecules (Cockerill et al., 1995). The inverse association between HDL-C and atherosclerosis is widely reported, however HDL-C sub-fractions and alterations to the reverse cholesterol transport system in insulin resistance and type II diabetes is the subject of ongoing research (Borggreve, De Vries, & Dullaart, 2003). In the present study, in general the strongest correlation between body composition and lipid profile included WC and WHtR, such that a lower WC and WHtR correlated positively with a more favourable lipid profile. These findings are in agreement with a large body of evidence reporting an increase in CVD risk associated with central adiposity

The ACSM risk stratification tool was used to group individuals into low and moderate CVD risk groups by identifying multiple CVD risk factors and describing CVD risk according to risk factor burden. Multivariable risk stratification is supported and recommended for predicting future CVD events in individuals (Belanger AM et al., 1998) and is based on the original findings of the Framingham Study (Kannel et al., 1961). Although the risk factors associated with CVD have been investigated extensively in US firefighter populations (Glueck et al., 1996; S. N. Kales et al., 2009; Murphy et al., 2002; Soteriades et al., 2005; Soteriades, Targino, et al., 2011), limited investigations involving health characteristics and lifestyle behaviours have been completed among UK firefighter populations (Munir et al., 2012). Furthermore, inflammation among firefighters has only been investigated once previously and found elevated CRP levels among obese compared to non-obese participants (Smith et al., 2012).

To our knowledge, no previous investigations have compared lipid profiles or inflammatory biomarkers using CVD risk stratified groups of UK firefighters. In the present study, as expected compared to moderate CVD risk respondents, healthier lipid profiles were more common among low CVD risk respondents. Somewhat unexpectedly, CRP and IL-6 concentrations did not differ significantly between CVD risk groups, which may have been an artifact of the study cohort reporting higher physical activity levels compared with the total firefighter group. The differences in lipid profile may be a precursor to future

progression of CVD, particularly in the absence of inflammatory differences. Blood lipids have been shown to correlate with differences in health characteristics and lifestyle behaviours between groups of youths (Suter & Hawes, 1992). It is well understood that CVD risk increases according to risk factor burden and length of exposure. The differences in lipid profiles may therefore be more as a result of differences in health characteristics (BF%, FM, WC) and physical activity levels than age.

Physical activity is understood to have an inverse association with inflammation, as indicated by lower concentrations of CRP and IL-6 among more active individuals compared to sedentary (Colbert et al., 2004; Ford, 2015). Hepatic synthesis and secretion of CRP occurs primarily from IL-6 signaling (Heinrich et al., 1990) and elevated levels are reported in overweight and obese (Visser, Mcquillan, Wener, & Harris, 1999). In the present study when participants were divided into quartiles for FM and BF%, compared with the lowest quartile, both CRP and IL-6 were higher in respondents in the highest quartile groups. This is in agreement with the literature suggesting that the pathophysiology of subclinical inflammation results in higher circulating levels of cytokines and their mediators (Festa et al., 2001). However, despite differences in FM and BF%, when compared according to CVD risk group only TNF α concentrations differed significantly. This may be partly explained by previous research finding TNF α concentrations to be less sensitive to between subject variations in physical activity level (Colbert et al., 2004) and more affected by the actions and amount of adipose tissue depots (Gokhan S Hotamisligil, Arner, Caro, Atkinson, & Spiegelman, 1995).

Although both IL-6 and TNF α are expressed within adipose tissue, only IL-6 is released into the circulatory system via this pathway. In the present study, compared to IL-6 and CRP, TNF α had slightly weaker correlations with body composition and current research suggests TNF- α action on adipose tissue is mediated via autocrine-paracrine mechanisms rather than endocrine (Coppack, 2001). Whereas IL-6 is thought to be responsible for signaling the state of adipose tissue to the rest of the body via endocrine pathways, following synthesis by TNF α within adipose tissue (Trayhurn & Wood, 2004) but the relationship is not fully understood. Also the quartile comparisons of serum IL-6,

CRP and TNF α grouped by BF% and FM in the present study support previous research findings of different signaling pathways for these inflammatory cytokines; compared to TNF α , serum concentrations of IL-6 and CRP showed clearer statistical differences for both BF% and FM at Q1 and Q2.

A sub-sample of respondents to a health and lifestyle survey provided blood samples to investigate lipid profiles and measure inflammatory markers associated with CVD risk. The ACSM risk stratification tool was used to group individuals according to low and moderate CVD risk and make comparisons according to health characteristics and lifestyle. The sub-sample, by comparison with the complete FF sample (chapter 3), had healthier body composition values, higher reported physical activity levels and psychological wellbeing scores, which may have confounded investigations. However, significant differences were found in markers of inflammation and lipids between FF grouped according to CVD risk and between the highest and lowest quartiles for adiposity. The results of this study suggest that FF would likely benefit from lifestyle intervention aimed at reducing adiposity. A reduction in adiposity may result in fewer FF presenting as moderate CVD risk with adverse lipids in the short term and impact inflammatory levels in the long-term.

CHAPTER 8

General Discussion

8.1 General Discussion

Study 1 (Chapter 4)

Aim: Describe the health characteristics and lifestyle behaviours of UK FRS employees according to predefined job roles and test for between group mean differences in health, lifestyle and wellbeing.

Key Findings:

- FF reported more favourable lifestyle behaviours (higher weekly physical activity, fewer smokers), lower prevalence of chronic disease risk (hypertension), but a higher prevalence of 'at risk' alcohol consumption.

Study 2 (Chapter 5)

Aim: Test for independent determinants of psychological wellbeing among UK FRS employees in differing job roles.

Key Findings:

- Sleep and self-rated health were found to be statistically significant independent determinants of psychological wellbeing in FRS employees irrespective of job role.

Study 3 (Chapter 6)

Aim: Describe CVD risk among FF respondents and make between CVD risk group comparisons for health characteristics, lifestyle behaviours and psychological wellbeing.

Key findings:

- FF classified as low CVD risk reported higher psychological wellbeing and improved sleep behaviours.

Study 4 (*Chapter 7*)

Aim: Compare objective markers of cardiometabolic risk between FF classified as low and moderate CVD risk and FF grouped according to high and low quartiles of adiposity.

Key Findings:

- FF classified as low CVD risk had a lipid profile and lower serum marker of inflammation (TNF α) associated with more favourable cardiometabolic health.
- FF in the lowest FM quartile reported less sedentary behaviour (daily sitting) and had higher serum concentrations of HDL-C.

The presented research has progressed the understanding of factors important for health and wellbeing among UK FRS employees employed in different job roles. As discussed FRS employees have considerable variation in shift working and physical fitness standard requirements. Yet considering the different occupational environments (shift working) and lifestyle behaviours (physical activity) (chapter 1), the similarities (sleep and SRH) in determinants of health and wellbeing were interesting (chapter 2) and perhaps infers a complex system such that the behaviour of the whole (UK FRS population) is more than the sum of its individual parts (employees engaged in differing job roles). Application of complex theory science may give further insights and understanding of determinants of health and wellbeing among UK FRS employees.

As discussed previously, the prognostic ability of a single global health question is well documented (van der Linde et al., 2013) and has been demonstrated in demographically and ethnically diverse populations in a variety of occupational settings including the military (Haddock et al., 2006; McGee, Liao,

Cao, & Cooper, 2017; Meng & D'Arcy, 2016). This has stimulated a large body of research including making comparisons with the use of objective markers of health (Rutledge et al., 2010), discussions regarding the concept of health (Huber et al., 2011) and proposals for a more person-centered (Huber et al., 2016) and integrated (Witt et al., 2017) approach to health. Integrated health represents a more expanded approach to health that respects physical and social environments and considers both in the context of individual and population health. Health professionals supporting FF within the UK FRS may benefit from a more expansive approach to wellbeing. However the UK FRS has traditionally employed a more reductionist approach to health and wellbeing, such that standards are typically measured by the achievement of fitness and described in terms of health characteristics. The transition to a more person-centered approach to health would require support at both a local (Fire Service/ Fire station) and national (National Fire Chiefs Council) level.

Results from study 1 identified statistically significant differences in lifestyle behaviours (PA, alcohol, smoking, daily sitting) and health characteristics (chronic disease prevalence) between UK FRS employees in different job roles. Identifying between job role differences is important for understanding differences in health outcomes. Yet identifying SRH as an independent determinant of wellbeing irrespective of FRS role (study 2) suggests that the sole use of objective health markers might fail to gather useful information, which is perhaps an artifact of the complex interaction of individual characteristics within different occupational environments.

Differences in the predictive ability of SRH have also been reported. For instance SRH has been most strongly associated with mortality from diabetes and respiratory disease, with moderate associations for mortality from heart disease, some cancers and stroke (Reindl et al., 2004). The possibility of individuals correcting for healthy, or unhealthy, lifestyle behaviours was considered and although attenuated slightly, the relationship remained after adjustment (Reindl et al., 2004), which points towards SRH as an intrinsic measure of health status. In the present study, SRH correlated with both body composition and psychological wellbeing (study 2) and differed significantly between CVD risk groups, such that health was rated more highly among low

CVD FF in study 3 compared to moderate and high CVD risk groups. Although SRH did not differ significantly between low and moderate CVD risk groups in study 4, the sample population mean SRH was higher than that of the whole FF sample. The findings in the present study support the predictive utility of SRH for both physiological and psychological health status. Health professionals within the UK FRS would likely be better informed of the wellbeing experience of FRS employees by including self rated health in routine health assessments.

It was somewhat surprising that sleep behaviours did not differ between the occupational groups, considering the different shift working practices in use within the UK FRS. This may have been a result of population bias such that FF more suited to shift working are likely to remain in role (healthy survivor). A decrease in emergency incidents attended may have reduced potential between group effects of shift work on sleep behaviour. The number of emergency incidents attended by the FRS has declined significantly (34%) during the last decade (Home Office, 2018), which would likely reduce the number of emergency incidents, and associated sleep disturbance, during a night shift. The present research gathered detailed information on the shift pattern of employees. This allowed some prediction on expected weekly night shifts. However, interpretation of some of the shift patterns used would likely vary between employees in different FRS job roles. Although this was considered in the present study, it was not possible to account for respondents that considered their FRS role as non-operational and as such selected the AS role. It is anticipated that any merging of FRS roles, if at all would have been minimal and respondents could not have been represented in more than one FRS role.

It was unexpected that serum concentrations of inflammatory biomarkers did not differ more markedly between CVD risk groups in study 4. IL-6 is the primary driver of hepatic CRP stimulation (Heinrich et al., 1990), and so no difference in systemic concentrations of CRP was likely a result of similarities in IL-6 concentrations. Whereas systemic concentrations of TNF α differed significantly between the low and moderate CVD risk groups, perhaps as a result of differences in adiposity (FM; $g=1.06$). However this relationship requires further investigation, as TNF α did not differ significantly between FF in the lowest and highest BF% and FM quartiles. Further research should aim for a

larger cohort with clearer stratification of physical activity, BF% and FM measures.

In contrast to less clearly defined differences in systemic biomarker concentrations, lipid profiles differed significantly (moderate effect size) between the low and moderate CVD risk groups (study 4). Inflammatory biomarker concentrations may differ in response to lifestyle behaviours such as sleep behaviour, smoking, and physical activity participation (Pearson et al., 2003). In the present study, to improve accuracy, blood samples were consistently collected on waking in the fasted state and participants were advised to refrain from eating, smoking and any exercise prior to sampling. It was understood that some on-duty FF participants had been involved in emergency response activities during the night shift prior to blood sampling, although data was not formally collected. Lipid concentrations are more stable over time. However, TG concentrations are subject to daily fluctuation (up to 30% variation), which is one of the reasons suggested for failing to independently predict CVD risk (Evans & Laker, 1995). Total cholesterol and HDL are less prone to daily fluctuations and low HDL-C concentrations are mostly reported as more predictive of CVD risk than TG concentrations (Frayn, 2005). In the present study both mean systemic TC and HDL-C concentrations were significantly higher among the low CVD risk group compared to the moderate CVD risk group. The results of the present study support the use of lipid measurement as part of the standard health screening of FF. The use of repeated measurements should be considered when risk is identified and assessed in combination with body composition measures.

As discussed previously, FF are required to operate in unpredictable environments that often involve physically and psychologically demanding tasks. Operational tasks may be short duration or protracted and may be required repeatedly in any particular shift, or involve prolonged periods of inactivity. Considering the physical demands of emergency response activities and maintenance of appropriate occupational fitness standard (Siddall et al., 2016; Stevenson et al., 2017), it was perhaps not surprising that compared to AS and EC, FF reported significantly higher physical activity participation, particularly vigorous intensity. In a 13-year follow-up study among Finnish FF, compared to

those that exercised 1 to 2 times per week, those that engaged in regular physical activity (4 to 7 sessions per week) were almost 4 times more likely to experience a decrease in cardiorespiratory fitness at follow-up (Punakallio, Lindholm, Luukkonen, & Lusa, 2012). Although cardiorespiratory fitness was not measured in the present study, given the association between cardiorespiratory fitness and physical activity participation among FF populations elsewhere and the differences both between FRS roles (study 1) and according to CVD risk classification (study 3) it is likely that increasing physical activity participation among some FRS groups would improve cardiometabolic health.

Daily sitting time differed significantly both between FRS employees in different FRS roles (study 1) and employees in different CVD risk groups (study 3 and study 4). The largest effect size was measured in daily sitting time between FRS roles ($p < 0.05$; $g = 1.16$ & 0.77 : for FF compared to EC and AS). In particular EC reported daily sitting of, on average, in excess of three hours more compared to FF. In the present study time spent sitting was used as a proxy for sedentary behaviour (Buckley et al., 2015), typically classified as activity ≤ 1.5 METS (Gibbs, Hergenroeder, Katzmarzyk, Lee, & Jakicic, 2015). There is some discussion whether increasing adiposity and CVD risk among general populations is a consequence of decreasing physical activity, or increasingly sedentary behaviours that is independent of physical activity participation effects (Ekelund et al., 2016). However population health guidelines are generally in agreement that a combination of physical activity participation and reduction in sedentary time is most effective for cardiometabolic health and lower chronic disease risk (Department of Health, 2011). In the present study, differences in cardiometabolic health (lipid profile) and sedentary behaviour (daily sitting) between low and moderate CVD risk groups (study 4) suggest that health interventions aimed at reducing sitting time may result in improved cardiometabolic health. In a study using primary care patients assessed as being at a high risk of diabetes, sedentary time was positively associated with cardiometabolic outcome (higher 2 hour fasted plasma glucose concentration and TG, lower HDL-C) and breaks in sedentary time were negatively associated with measures of adiposity (Henson et al., 2013). Increasing physical activity participation and decreasing sedentary time may result in combined benefits for

cardiometabolic and vascular health (Duvivier et al., 2018). Markers of endothelial dysfunction (endothelial adhesion molecules) were improved following four days of structured physical activity (one hour/day). However, markers of metabolic health (lipids) were only improved when daily sitting was replaced with light physical activity (5-6 hours/day) where light physical activity was a combination of walking (2-4 hours/day) and standing (2-3 hours/day). In the context of results from study 4, the findings of Duvivier et al, would suggest that FRS health professionals may best improve cardiometabolic health outcomes by identifying FRS employees that both report higher levels of daily sitting time and reduced physical activity participation and test interventions to aimed at improving both these behaviours. This approach would give further insight and understanding of overall daily movement patterns and perhaps extend the reach of UK FRS health professionals by influencing physical activity behaviours beyond the 'gym-based fitness session'.

As mentioned previously, more than half of UK adults do not achieve the recommended weekly physical activity amount (≥ 30 minutes of moderate intensity exercise on ≥ 5 days/week) and due to the methodological challenges of measuring physical activity behaviours by self-report (Helmerhorst, Brage, Warren, Besson, & Ekelund, 2012), the true figure may be as low as 5% (Department of Health, 2011). It is important to consider the possibility of mis-reporting in the present study; FF were more likely to achieve the minimum weekly physical activity level for health than other FRS roles and reported less daily sitting than other FRS roles. These findings coupled together support the overall interpretation that occupational role and environment influence lifestyle behaviour. In this respect for the present study, the comparative findings of physical activity behaviours between FRS roles are perhaps of greater interest than the reported physical activity levels.

Future research

Firefighting is rightly characterised as a challenging occupation with aspects of the job role that require both physical and psychological preparedness and the mitigation of risk during emergency response is key for firefighter safety. Conducting research in such a dynamic and unpredictable occupational

environment is challenging. The present study was ambitious in administering a large self-reported questionnaire to facilitate the capturing of health and lifestyle data that was representative of the various job roles within the UK FRS. Although the health and lifestyle survey was comprised of previously validated questionnaires, future research requires validation of the present survey format. The findings of which would determine the use of the survey in measuring any intervention outcomes. Future research may benefit from the results of the present study in developing bespoke lifestyle interventions that are sensitive to the different occupational environments within the FRS. For example among AS and EC interventions should aim at increasing physical activity and reducing sedentary behaviours across all employees. Whereas among FF employees, a more targeted approach should in the first instance involve identifying individuals reporting lower physical activity participation and increased sedentary behaviour. Both interventions should involve objectively measuring physical activity to improve on the present study self report method. Objective measurements should also be used to compare sleep behaviours between FRS roles and cohort of FF whose sleep is monitored in the fire station setting and blood samples taken would be appropriate. The self report method of the present study prevented collecting data on the amount of sleep disturbance resulting from emergency response and future research should aim to improve on this.

Future research should also give consideration to the bespoke occupational environment of FF. For example station activity levels (emergency incidents) should be noted, with particular attention to the number of turnouts at night. Further 'exposure' details should be noted for each employee to account for shift rotation and annual leave. Provision and access to on-station fitness facilities should be recorded and how much physical activity is completed during a typical shift. This should be replicated among all FRS roles. The data gathered may provide further understanding of the interplay between the nature of the work environment and physical activity patterns.

Conclusion

This body of research measured differences in lifestyle and health between FRS employees in differing job roles. Operational firefighters involved in emergency response present on average as a healthier group in comparison with other FRS roles. However risk factors associated with adverse cardiometabolic health were identified among a significant group of operational firefighters. FRS health professionals motivated to lower the cardiac event risk associated with emergency response may be best advised to identify this FF group prior to lifestyle intervention.

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Appendices

Appendix A – Health and lifestyle survey

Who is responsible for this survey?



* 1. The University of Bath are responsible for administering and analysing the results of this survey, which was funded and commissioned under a joint grant from the FireFit Steering Group, the Chief Fire Officer's Association and the Fire Research & Training Trust. The FireFit Steering Group is made up of Fire & Rescue Service employees that consist of fitness advisers, occupational health advisers, health & safety advisers and operational personnel. The group contributes to the development of fitness and health within the Fire & Rescue Service by improving the understanding of firefighter health and fitness and sharing scientific knowledge and best practice across the UK. Their main goals have been to ensure that UK Fire & Rescue Services put in place appropriate measures to ensure that firefighters have the correct physical requirements to be able to perform their roles safely and effectively, thus ensuring firefighter wellbeing. Recently, the FireFit Steering Group has become aligned with the work of the Chief Fire Officers Association and have recently collaborated to develop fitness standards for the UK Fire & Rescue Services.

Aims of this survey

The aim of the survey is to gather information on the health and lifestyle choices made by the employees of the UK Fire and Rescue Service. It is anticipated that this information will enable a more complete understanding of the effect that lifestyle choices have on the health and wellbeing of Fire and Rescue employees. It is widely agreed that to successfully achieve good health and wellbeing you must consider more than physical exercise. Therefore in addition to physical activity levels, the survey is designed to report on nutrition, smoking, alcohol, psychological wellbeing and sleep patterns. Understanding these areas will enable a more structured and detailed approach to achieving good health and fitness for all Fire and Rescue Service employees.

The following survey is completely anonymous and you will not be expected to share any information about yourself that may directly identify you.

- ☐ By ticking this box you are confirming that you are happy to proceed and complete the survey and understand that the results of this survey will be used for research purposes.

Section 1: General information

* 2. What is your age?

Years

Age

* 3. What is your sex?

- ☐ Male
- ☐ Female

4. What is your ethnic origin?

- | | | |
|---|---|---|
| <input type="radio"/> British (white) | <input type="radio"/> White & Asian (mixed ethnicity) | <input type="radio"/> Other (Asian/Asian British) |
| <input type="radio"/> Irish (white) | <input type="radio"/> White & Asian (mixed ethnicity) | <input type="radio"/> African (Black/African/Caribbean/Black British) |
| <input type="radio"/> Gypsy/traveller (white) | <input type="radio"/> Other (mixed ethnicity) | <input type="radio"/> Caribbean (Black/African/Caribbean/Black British) |
| <input type="radio"/> European (white) | <input type="radio"/> Indian (Asian/Asian British) | <input type="radio"/> Other (Black/African/Caribbean/Black British) |
| <input type="radio"/> Other (white) | <input type="radio"/> Pakistani (Asian/Asian British) | <input type="radio"/> Arab (other ethnic group) |
| <input type="radio"/> White & Black Caribbean (mixed ethnicity) | <input type="radio"/> Bangladeshi (Asian/Asian British) | |
| <input type="radio"/> White & Black African (mixed ethnicity) | <input type="radio"/> Chinese (Asian/Asian British) | |

* 5. What is your postcode area?

Area

Postcode area

6. How long have you worked for the Fire Service?

Years

Length of service

* 7. Which Fire and Rescue Service are you employed by?

Fire and Rescue Service

Choose from the drop down menu

8. What bracket does your salary fall within?

- ☐ Under £10,000
- ☐ £10,000 to £23,999
- ☐ £23,999 to £28,999
- ☐ £29,000 to £31,999
- ☐ £31,000 to £34,999
- ☐ £35,000 to £40,999
- ☐ £41,000 to £39,999
- ☐ £40,000 to £46,999
- ☐ £47,000 to £54,999
- ☐ £55,000 to £64,999
- ☐ £65,000 and above

9. What shift system do you work?

- ☐ 1-3 (24hrs, 3 rota days)
- ☐ 2-2-4 (2 days, 2 nights, 4 rota days)
- ☐ Self rostering
- ☐ Day crewing
- ☐ Day crewing plus
- ☐ Retained
- ☐ Flexi-duty
- ☐ 9 day fortnight
- ☐ 10 day fortnight
- ☐ Part-time

* 10. Which of the options below best describes your Fire Service role?

- ☐ Operational
- ☐ Control
- ☐ Support staff

* 11. What is your height? (Remove shoes before measuring.)

ft/in/cms

Height

* 12. What is your weight? (unclothed)

st/lb/kg

Weight

* 13. What is your waist measurement?

Inches/cm

Waist size

* 14. How do you rate your overall health?

☐ Excellent ☐ Good ☐ Fair ☐ Poor

* 15. Do you, or have you ever, suffered from any of the following?

Please tick all that apply.

☐ None

☐ Heart condition

☐ Diabetes

☐ Stroke

☐ Irritable Bowel Syndrome

☐ Chronic chest disorder

☐ High blood pressure

☐ Low blood pressure

Other (please specify)

Section 2: Lifestyle (physical activity)

Physical Activity

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 DAYS. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the VIGOROUS activities that you did in the LAST 7 DAYS. VIGOROUS physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think ONLY about those physical activities that you did for at least 10 minutes at a time.

- * 16. During the LAST 7 DAYS, on how many days did you do VIGOROUS physical activities like heavy lifting, digging, aerobics, or fast bicycling? (If no vigorous activities, answer "0" and skip to question 18).

Days/week

Number of days per week

17. How much time did you usually spend doing VIGOROUS physical activities on one of those days? (If not sure, answer with an "X" in the appropriate box).

Hours per day

Minutes per day

Don't know/Not sure

Think about all the MODERATE activities that you did in the LAST 7 DAYS. MODERATE activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

- * 18. During the LAST 7 DAYS, on how many days did you do MODERATE physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking. (If no moderate activities, answer "0" and skip to question 20)

Days/week

Number of days per week

19. How much time did you usually spend doing MODERATE physical activities on one of those days? (If not sure, answer with an "X" in the appropriate box).

Hours per day

Minutes per day

Don't know/Not sure

Think about the time you spent WALKING in the LAST 7 DAYS. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

* 20. During the LAST 7 DAYS, on how many days did you WALK for at least 10 minutes at a time? (If no walking activities of at least 10 minutes, answer "0" and skip to question 22).

Days/week

Number of days per week

21. How much time did you usually spend WALKING on one of those days? (If not sure, answer with an "X" in the appropriate box).

Hours per day

Minutes per day

Don't know/Not sure

The last question is about the time you spent SITTING on weekdays during the LAST 7 DAYS. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

* 22. During the LAST 7 DAYS, how much time did you spend SITTING on a WEEK DAY? (If not sure, answer with an "X" in the appropriate box).

Hours per day

Minutes per day

Don't know/Not sure

Section 2: Lifestyle (nutrition)

The following section covers nutrition. Please answer each question according to an AVERAGE WEEK.

* 23. In an AVERAGE WEEK how often did you....

	Usually/Often	Sometimes	Rarely/Never
Skip breakfast?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat 4 OR MORE meals from sit-down or take-out restaurants?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat MORE THAN 3 SERVINGS of whole grain products a day? (SERVING = 1 slice of 100% whole grain bread; 1 cereal bowl of whole grain cereal like Shredded wheat, Weetabix, All-bran, oatmeal, 3 to 4 whole grain crackers, 1/2 cereal bowl of brown rice or whole wheat pasta).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat MORE THAN 2-3 SERVINGS of fruit a day? (SERVING = 1/2 cereal bowl of small fruit (grapes, berries etc or 1 medium fruit or a glass of 100% fruit juice)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat MORE THAN 3-4 SERVINGS of vegetables/potatoes a day? (SERVING = 1/2 cereal bowl of vegetables or potatoes, or 1 cereal bowl of leafy vegetables)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat or drink MORE THAN 2-3 SERVINGS of milk, yogurt, or cheese a day? (SERVING = 1/2 pint of milk or yogurt; matchbox size of cheese)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat beef, pork, or dark meat chicken (leg and thigh)?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat FRIED FOODS such as fried chicken, fried fish, French fries or chips?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Add BUTTER, MARGARINE OR OIL to bread, potatoes, rice or vegetables at the table?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat sweets like cakes, cookies, pastries, donuts, muffins, chocolate and jelly sweets MORE THAN 2 TIMES PER DAY?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
DRINK 500ML OR MORE OF non-diet fizzy drinks, such as Coke or Lemonade, or fruit drinks, such as Sunny Delight, a day? (1 can of fizzy drink = 330ml)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat high salt PROCESSED FOODS like canned soup or pasta, frozen/package meals (TV/microwave dinners etc), chips?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ADD SALT to foods during cooking or at the table?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 24. In an AVERAGE WEEK how often did you

	Usually/often	Sometimes	Rarely/never	Do not consume this food
Use SEMI-SKIMMED or WHOLE MILK instead of SKIMMED (NO FAT) milk?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use REGULAR CHEESE like Brie, Cheddar, Red Leicester, Stilton instead of LOW FAT or part skim cheeses as a snack, on sandwiches, pizza etc?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat MORE THAN 170 GRAMMES of meat, chicken, turkey or fish PER DAY? (NOTE = 170 grammes of meat or chicken is the size of 2 decks of cards or the same as the following: 2 x regular hamburger, 2 x chicken breast or leg, 2 x pork chop.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Choose HIGHER FAT RED MEATS like prime rib, T-bone steak, hamburger, ribs etc. instead of lean red meats?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat the SKIN on chicken and turkey or the FAT on meat?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use REGULAR PROCESSED MEATS (like salami, corned beef, hotdogs, sausage, bacon) instead of low fat processed meats (like roast beef, turkey, lean ham, low-fat cold cuts/hotdogs).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat REGULAR CRISPS, NACHOS, TORTILLA, CHIPS, CRACKERS, POPCORN, NUTS instead of low-fat crisps or low-fat crackers?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use REGULAR SALAD DRESSING AND MAYONNAISE instead of low-fat or fat-free salad dressing and mayonnaise?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
COOK WITH OIL, BUTTER OR MARGARINE instead of using non-stick sprays like Crisp 'n Dry or cooking without fat?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
USE REGULAR SWEETS like cake, cookies, pastries, doughnuts, muffins, and chocolate instead of LOW FAT OR FAT-FREE sweets?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eat REGULAR ICE-CREAM instead of low-fat or fat-free ice cream, frozen yogurt etc?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 25. Do you regularly take any supplements?

☐ Yes ☐ No (Go to question 27)

26. What/which supplement(s) do you take?

- ☐ Combined multivitamin and mineral supplement
- ☐ Individual vitamin supplement (eg. vitamin C, D)
- ☐ Individual vitamin mineral supplement (eg. iron, calcium)
- ☐ Fish oils (e.g., cod liver oil)
- ☐ Protein
- ☐ Creatine

Other (please specify)

Section 3: Lifestyle (alcohol)

The following questions are about how much alcohol you may consume. Please answer honestly.

Consider a drink to be 1/2 a pint of cider, beer or lager, a shot of spirit (e.g.. vodka, gin, rum etc), a glass of wine, a bottle of alcopop.

* 27. How often did you have a drink containing alcohol in the past year?

☐ Never ☐ Monthly or less ☐ 2-4 times a month ☐ 2-3 times a week ☐ 4 or more times a week

* 28. How many drinks did you usually have on a typical day/night when you were drinking in the past year?

☐ 0 ☐ 1 or 2 ☐ 3 or 4 ☐ 5 or 6 ☐ 7 or 9 ☐ 10 or more

* 29. How often do you have six or more drinks on one occasion?

☐ Never ☐ Less than monthly ☐ Monthly ☐ Weekly ☐ More than once a week

Section 3: Lifestyle (smoking)

The following questions are about smoking history. If you have NEVER smoked tick NO to the next question and proceed to section 3.

* 30. Have you EVER smoked a cigarette (including roll-ups)?

☐ Yes (GO TO NEXT QUESTION) ☐ No (GO TO QUESTION 46)

31. How old were you when you first tried smoking a cigarette (including roll-ups) even if it was only a puff or two?

	Years
Age	<input type="text"/>

32. Do you smoke cigarettes AT ALL now (even if only occasionally)?

☐ Yes (GO TO NEXT QUESTION)
☐ No (GO TO QUESTION 40)

33. How often do you smoke AT THE MOMENT?

☐ Regularly - at least one cigarette/roll-up a day
☐ Occasionally - less than one cigarette/roll-up a day (GO TO QUESTION 45)

34. For how many years have you been smoking cigarettes (including roll-ups) on a REGULAR BASIS?

	Years
Number of years smoking	<input type="text"/>

35. Please rate your addiction to cigarettes on a scale of 0-100:

0 = I am NOT addicted to cigarettes at all
100 = I am VERY addicted to cigarettes

	Rating
Rating scale	<input type="text"/>

36. How many cigarettes do you usually smoke a day?

	Per day
Number of cigarettes	<input type="text"/>

37. How soon after waking up do you usually smoke your first cigarette or roll-up?

- ☐ Within first 5 mins
- ☐ 5-15 min
- ☐ 15-30 min
- ☐ 30 min - 1 hour
- ☐ 1 hour or more

38. For you, quitting smoking for good would be....

- ☐ Very easy
- ☐ Fairly easy
- ☐ Fairly difficult
- ☐ Very difficult
- ☐ Impossible

39. How much do you agree with this statement?

"After a few hours without smoking I
have a strong urge to have a cigarette"

- ☐ Totally disagree
- ☐ Fairly disagree
- ☐ Don't agree or disagree
- ☐ Fairly agree
- ☐ Fully agree

CURRENT SMOKERS: END OF QUESTIONS

Section 3: Lifestyle (smoking)

THOSE WHO HAVE TRIED SMOKING/EX-SMOKERS/OCCASIONAL SMOKERS.

(current regular smokers leave the rest of this page blank and go to section 3)

40. Did you use to smoke regularly (at least 1 cigarette/roll-up a day)?

- ☐ Yes
- ☐ No (GO TO QUESTION 45)

41. For how many years did you smoke cigarettes (including roll-ups) on a REGULAR BASIS?

Years

Number of years smoking

42. How many cigarettes (including roll-ups) did you use to smoke a day?

Per day

Number of cigarettes

43. How old were you when you STARTED smoking cigarettes (including roll-ups) on a REGULAR BASIS?

Years

Age

44. Roughly when did you STOP smoking cigarettes (including roll-ups) on a REGULAR BASIS?

- ☐ Less than 1 week ago
- ☐ 1 week - 1 month ago
- ☐ 1 - 6 months ago
- ☐ 6 - 12 months ago
- ☐ More than 1 year ago

45. When was the last time you smoked a cigarette (including roll-ups)?

- ☐ less than 1 week ago
- ☐ 1 week - 1 month ago
- ☐ 1 - 6 months ago
- ☐ 6 - 12 months ago
- ☐ More than 1 year ago

Section 3: Psychological wellbeing

The following section is designed to gather information on your psychological well being. Some of the questions may not appear to have much relevance to you in your role at work. However it is important you answer **HONESTLY** for a complete assessment to be made. Please answer each question according to your experience whilst **WORKING FOR THE FIRE SERVICE**.

* 46. Please read each statement and tick the one which indicates how much the statement applied to you **OVER THE PAST WEEK** or your last time spent **IN WORK** for the **FIRE SERVICE**. There are no right or wrong answers. Do not spend too much time on any statement.

	Did not apply to me at all	Applied to me to some degree, or some of the time	Applied to me to a considerable degree, or a good part time	Applied to me very much, or most of the time
I found it hard to wind down	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was aware of dryness of my mouth	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I couldn't seem to experience any positive feeling at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence physical exertion)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found it difficult to work up the initiative to do things	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I tended to over-react to situations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I experienced trembling (e.g. in the hands)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that I was using a lot nervous energy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was worried about situations in which I might panic and make a fool of myself	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that I had nothing to look forward to	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found myself getting agitated	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found it difficult to relax	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt down-hearted and blue	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Did not apply to me at all	Applied to me to some degree, or some of the time	Applied to me to a considerable degree, or a good part time	Applied to me very much, or most of the time
I was intolerant of anything that kept me getting on with what I was doing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt I was close to panic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was unable to become enthusiastic about anything	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt I wasn't worth much as a person	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that I was rather touchy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt scared without any good reason	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that life was meaningless	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Section 3: Psychological wellbeing

* 47. This scale consists of a number of words that describe feelings and emotions. Read each item and then indicate to what extent you have felt this way during the PAST WEEK or your last time IN WORK for the FIRE SERVICE.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Distressed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Excited	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Upset	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strong	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Guilty	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scared	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hostile	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Enthusiastic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Proud	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Irritable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Alert	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ashamed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nervous	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Determined	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Attentive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Jittery	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Active	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Afraid	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Section 3: Psychological wellbeing

* 48. Below are five statements with which you may agree or disagree. Using the options below choose your level of agreement.

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
In most ways my life is close to my ideal	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The conditions of my life are excellent	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am satisfied with my life	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
So far I have gotten the important things I want in life	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If I could live my life over, I would change almost nothing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Section 4: Sleep quality

The following questions relate to your sleep habits during the **PAST MONTH ONLY**. Your answers should indicate the most accurate reply for the **MAJORITY** of days and nights in the past month.

- * 49. During the past month, what time have you usually gone to bed at night?

Time

Bed time	<input type="text"/>
----------	----------------------

- * 50. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

Minutes

Time taken to fall asleep	<input type="text"/>
---------------------------	----------------------

- * 51. During the past month, what time have you usually gotten up in the morning?

Time

Getting up time	<input type="text"/>
-----------------	----------------------

- * 52. During the past month, how many hours of **ACTUAL SLEEP** did you get at night? (This may be different than the number of hours you spent in bed)

Hours

Hours of sleep per night	<input type="text"/>
--------------------------	----------------------

* 53. During the past month, how often have you had trouble sleeping because you.....

	Not during the past month	Less than once per week	Once or twice a week	Three or more times a week
Cannot get to sleep within 30 minutes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wake up in the middle of the night or early morning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Have to get up to use the bathroom	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cannot breathe comfortably	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cough or snore loudly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feel too cold	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other reasons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feel too hot	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Had bad dreams	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Have pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
'Other reasons'	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other (please specify)

* 54. During the past month, how would you rate your sleep quality overall?

- ☐ Very good
- ☐ Fairly good
- ☐ Fairly bad
- ☐ Very bad

Section 4: Sleep quality

* 55. How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently try to work out how they would have affected you. Use the following scale to choose the MOST APPROPRIATE NUMBER for each situation.

	Would never doze	Slight chance of dozing	Moderate chance of dozing	High chance of dozing
Sitting and reading	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Watching TV	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sitting, inactive in a public place (eg after theatre or a meeting)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
As a passenger in a car for an hour without a break	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lying down to rest in the afternoon when circumstances permit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sitting and talking to someone	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sitting quietly after a lunch without alcohol	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In a car, while stopped for a few minutes in traffic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* 56. The research team would like to invite you for further research. The research will involve conducting tests that will enable us to make a more detailed assessment of your health, on which you will receive confidential feedback. The tests will be conducted wherever possible at your place of work at a time convenient to you. If you would like to be involved please indicate below and include your contact details. Many thanks.

- ☐ Yes I would like to be involved in further research.
- ☐ No I would not like to be involved in further research.

If yes please give contact details (include your name and telephone number)

END OF SURVEY, many thanks for your time and cooperation.

Appendix B. Full scoring protocol for each questionnaire used within the health and lifestyle survey

Questionnaire	Variable	Outcome	Method	Question #	Units
IPAQ-Short form	Physical Activity	<i>Vigorous</i>	"8.0 x vig mins x vig days"	16 & 17	MET/Mins/week
		<i>Moderate</i>	"4.0 x mod mins x mod days"	18 & 19	MET/Mins/week
		<i>Walking</i>	"3.3 x walking mins x walking days"	20 & 21	MET/Mins/week
		<i>Sitting</i>	"Daily sitting"	22	Mins/day
REAP (short form)	Nutrition	<i>Total Fat</i>	Dining out	23_2	Sum score
			Milk	24_1	
			Cheese	24_2	
			6 oz meat/fish	24_3	
			Red meat choice	23_7	
			Red meats	24_4	
			Skin	24_5	
			Processed meats	24_6	
			Fried foods	23_8	
			Sweets/desserts	23_10	
			Sweets/desserts (2)	24_10	
			Ice cream	24_11	
			Snack foods	24_7	
			Salad Dressing	24_8	
			Added fat	23_9	
			Cooking with fat	24_9	
		<i>Saturated fat</i>	Dining out	23_2	Sum score
			Milk	24_1	
			Cheese	24_2	
			Red meats	24_4	
			Red meat choice	23_7	

			6 oz meat/fish	24_3	
			Skin	24_5	
			Processed meats	24_6	
			Sweets/desserts	23_10	
			Sweets/desserts (2)	24_10	
			Ice cream	24_11	
		<i>Cholesterol</i>	Milk	24_1	Sum score
			Cheese	24_2	
			Red meats	24_4	
			Red meat choice	23_7	
			Skin	24_5	
			6 oz meat/fish	24_3	
			Processed meats	24_6	
			Sweets/desserts	23_10	
			Sweets/desserts (2)	24_10	
			Ice cream	24_11	
		<i>Sodium</i>	Dining out	23_2	Sum score
			High salt processed foods	23_12	
		<i>Grains</i>	Grain servings	23_3	Sum score
		<i>Fruit</i>	Fruit servings	23_4	Sum score
		<i>Vegetable</i>	Vegetable servings	23_5	Sum score
		<i>Dairy</i>	Dairy servings	23_6	Sum score
		<i>Meat</i>	6 oz meat/fish	23_7	Sum score
AUDIT-C	Alcohol	<i>'Frequency</i>	"0 for never" to "4 for 4 or more times a week"	27	Sum score
		<i>Drinks'</i>	"0 for both 0 AND 1-2 drinks"	28	
		<i>'6 or more'</i>	"0-4"	29	
CDS-5	Smoking status	<i>Smoker</i>	"1" to question 33	33	
		<i>Former smoker</i>	"2" to question 32 AND "1" to 40	32	
				40	

DASS-21	Smoking dependency	<i>Non-smoker</i>	"2" to question 30 OR "2" to 32 & 40	30 32 40	Sum score
		<i>Addiction</i>	"quintiles 1-5"	35_1_1	
		<i>Cigs/day</i>	"quintiles 1-5"	36_1_1	
		<i>How soon</i>	"quintiles 5-1"	37	
		<i>Ease of quitting</i>	"5-1"	38	
		<i>Urge to smoke</i>	"1-5"	39	
	wellbeing	<i>Depression</i>	"0-3" for 7 items from "did not apply to me at all" to "applied to me very much, or most of the time"	46_10	Sum score
				46_13	
				46_21	
				46_17	
				46_16	
				46_3	
				46_5	
		<i>Stress</i>	"0-3" for 7 items from "did not apply to me at all" to "applied to me very much, or most of the time"	46_1	Sum score
				46_12	
				46_8	
				46_11	
				46_6	
				46_18	
				46_14	
		<i>Anxiety</i>	"0-3" for 7 items from "did not apply to me at all" to "applied to me very much, or most of the time"	46_19	Sum score
				46_2	
				46_4	
				46_7	
				46_9	
				46_15	
				46_20	

PANAS*	Mood	<i>Positive affect</i>	"1-5" for 10 items from "very slightly or not at all" to "extremely"	47_1 47_3 47_5 47_9 47_10 47_12 47_13 47_15 47_16 47_18	Sum score
		<i>Negative affect*</i>	"1-5" for 9 items from "very slightly or not at all" to "extremely"	47_2 47_4 47_6 47_7 47_8 47_11 47_13 47_14 47_17 47_19	Sum score
SWLS	Life satisfaction	Life satisfaction	"0-7" for 5 items from "strongly disagree" to "strongly agree"	50_1 50_2 50_3 50_4 50_5	Sum score
PSQI*	Sleep Quality	<i>Sleep efficiency</i>	"Q.52 divided by the difference between Q.49 & Q.51 and multiplied by 100" AND assign the following score: ">85% =0", "75-84%=1", "65-74%=2", "<65%=3"	49 51 52	

<p>*2 component items (medication & daytime dysfunction) were mistakenly omitted from the PSQI section, preventing the use of PSQI global. score.</p>		<p><i>Sleep Latency</i> Assign following score to Q.50 "(0-15 = 0, 15-30= 1, 30-60 = 2, >60=3)" & score Q.55_1 as "0_3" for 4 items from "not during the past month to three or more times a week". Sum total.</p>	50 55_1	
		<p><i>Duration of Sleep</i> Assign following score- ">7hrs=0, 6-7hrs=1, 5-6hrs=2, <5hrs=3".</p>	52	
		<p><i>Sleep Quality</i> Assign following score -'very good'=0; 'fairly good'=1; 'fairly bad'=2; 'very bad'=3.</p>	54	
		<p><i>Sleep Disturbance</i> Sum Q.55_1 to 55_9 and assign following score "sum=0 = 0, 1-9 = 1, 9-18=2, >18=3"</p>	55_1 55_2 55_3 55_4 55_5 55_6 55_8 55_9	Sum score
<p>ESS (Johns, 1992)</p>	<p>Sleepiness</p>	<p><i>Daytime sleepiness</i> "0-3"</p>	57_1 57_2 57_3 57_4 57_5 57_6 57_7 57_8	Sum score

Appendix C – UK Fire and Rescue internal communication circular on behalf of the Chief Fire Officer Association detailing the study aims and objectives and contents of health and lifestyle survey.



Circular

Title: UK FRS Health & Lifestyle Survey

Reference Number:

Date Issued:

For the attention of:

Distribution

CFOA Members ☐

Fire & Rescue Service ☐

General Public ☐

Relevant to:

England ☐

Northern Ireland ☐

Scotland ☐

Wales ☐

Related Documentation:

Further information or Discussion: philipturner@lancsfireandrescue.org.uk
justinjohnston@lancsfireandrescue.org.uk

Issued by: CFOA HQ

Approved by:

Summary

The CFOA FireFit Steering Group in collaboration with the University of Bath are involved in a National Fitness Standards Research Project. The research aims to provide guidance on fitness standards and lifestyle advice for UK FRS employees. For health and lifestyle advice to be relevant to UK FRS employees it is first necessary to collect information on the health and lifestyle choices made by employees of the UK FRS. It is widely agreed that to successfully achieve good health and

wellbeing you must consider more than physical exercise. In collaboration with the University of Bath a Health and Lifestyle Survey has been designed to provide a snapshot of the health status of the UK FRS. Therefore in addition to physical activity levels, the survey has been designed to collect information on nutrition, smoking, alcohol, psychological wellbeing and sleep patterns. Understanding these areas will enable a more structured and detailed approach to achieving good health and fitness for all FRS employees. The information will enable further understanding of the effects that lifestyle choices have on the health and wellbeing of FRS personnel and will be used to improve health and wellbeing services. FRSs that participate in the survey will have the opportunity to receive a confidential report once the survey has ended. However FRSs will not be able to identify their employees from any data provided. All results reported nationally will be on a generic basis.

Benefits to your Fire & Rescue Service

The Health and Lifestyle Survey represents a unique opportunity to receive a confidential snapshot of the health and well being of your employees, which will assist your service in improving your health & wellbeing services. For this to be possible participation needs to be sufficiently high. The more responses that can be collected, the more this will contribute to the understanding of the health & lifestyles of service employees both in your FRS and nationally. The research team would therefore like to emphasise that survey responses are required in adequate numbers and hope you will support the project by promoting this survey to all staff. We would also like to encourage that communication to staff emphasises the neutrality, confidentiality and intended use of the survey results. A statement relating to this can be found in the implementation guidelines (Appendix 1).

Data handling / Ethical Considerations

The Health and Lifestyle Survey has received **ethics approval** from the **University of Bath**, which ensures academic standards and data protection requirements. For further details of University of Bath ethics committee see:

<http://www.bath.ac.uk/internal/ethics/committee/#rules>

The Health and Lifestyle Survey is anonymous and voluntary. Staff will not be expected to share any information that may directly identify them to the FRS. The survey is for all FRS employees (Operational, Support and Control Staff). The Health and Lifestyle Survey is an online survey. However a paper version can be downloaded from <http://www.firefitsteeringgroup.co.uk/Survey.pdf>. Wherever possible the project team would encourage you to provide access to the on-line form. **If paper copies are made available to your staff, we would ask that these are transcribed to the on-line forms within your Service, as unfortunately the project team do not have the capacity to perform this function.**

Data Protection

The survey uses Survey Monkey as a web host: a reliable online and commonly used survey tool. Further details concerning security and data protection can be found at

<http://www.surveymonkey.net/mp/policy/security/>

Data Reporting

The results of the National Health and lifestyle Survey will be made available to all UK FRSs. Any reported results will not be used to identify individual FRSs. Participating FRSs will have the opportunity to receive confidential reports. Each report will feedback on results from the employees of the FRS in question and will only be reported to individual FRSs.

Appendix D – Update on response to the health and lifestyle survey as a Chief Fire Officer Association circular.



CFOA
Publications

Circular

Title: UK FRS Health
& Lifestyle Survey
progress report

Reference Number:

Date Issued:

For the attention of:

Distribution

CFOA Members ☐

Fire & Rescue Service ☐

General Public ☐

Relevant to:

England ☐

Northern Ireland ☐

Scotland ☐

Wales ☐

Related Documentation:

Further information or Discussion: philipturner@lancsfirerescue.org.uk
justinjohnston@lancsfirerescue.org.uk

Issued by: CFOA HQ

Approved by:

Background

As part of the national fitness standards research project and as covered in the previous CFOA circular the UK FRS Health & Lifestyle Survey was released nationally in Feb 2013. The survey combines a number of previously validated and reliable questionnaires to report on the lifestyle factors considered significant in determining health status. Although not exclusively, such factors include physical activity levels, nutritional intake, smoking status, alcohol intake, psychological well

being and sleep quality. Large scale population studies suggest that cardiovascular disease risk is adversely affected when these factors deteriorate. More specifically, recent evidence suggests an increase risk of cardiac event associated with the physiological strain of emergency response.

Subject to response numbers FRSs that participate in the survey will have the opportunity to receive a confidential report. However FRSs will not be able to identify their employees from any data provided. All results reported nationally will be on a generic basis.

The survey represents a unique opportunity to describe the health status of the UK FRS by using previously validated and reliable statistical tools and is the first time a health audit of this nature has been conducted. Each FRS has the opportunity for comparison against national data and in doing so can both inform and compliment respective health and well being services. For each FRS to have the opportunity of comparison against national results it is important that responses are in sufficient numbers. Increasing the number of responses both strengthens the national data set and the statistical confidence with which comparisons can be made. There is no limit on response numbers however for meaningful comparisons to be made each FRS should aim for at least 160 responses.

Update

The UK FRS Health & Lifestyle Survey has been running for approximately 2 months and has reached a total of **1800 fully completed responses**. It is intended to run the survey until **July 2013**. It should be noted that the greater proportion of employees an individual FRS can encourage to participate in the survey the greater the level of statistical confidence both in individual results and any comparison with the national results. For a full breakdown of survey responses by FRS please refer to *appendix 1* (attached). Following this circular a further update will be available before July by contacting a member of the research team.

For guidance on implementing the survey please refer to *appendix 2* (attached). When encouraging staff to participate in the survey it is important to emphasise the neutrality, confidentiality and intended use of the survey results.

Appendix E – Participant information for blood sampling study

Participant Information Sheet

Assessing the health and lifestyle of the UK Fire and Rescue Service

We would like to invite you to take a further part in a research study following the completion of a health and lifestyle survey. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Feel free to ask us if there is anything that is not clear or if you would like more information. Thank you for taking the time to decide whether or not you wish to take part.

What is the purpose of the study?

Following the health and lifestyle survey, to enable a more detailed assessment of health risk it is necessary to obtain a blood sample to examine an array of biochemical markers of health. We are interested in measuring these biochemical markers to investigate whether lifestyle is associated with physiological health in firefighters.

Why have I been chosen?

You have been chosen because you are a UK Fire and Rescue Service employee and you have demonstrated a willingness to take part in further health tests following your completion of the Health and Lifestyle Survey.

Do I have to take part?

You should only take part if you want to. You have expressed interest in taking part upon completion of the online Health and Lifestyle Survey. However, you may choose to reconsider your participation and withdraw from the study at any time.

What will happen to me if I take part?

If you decide to take part, you will be given this information sheet to keep and we (the research team) will make arrangements to visit your place of work or other suitable venue to carry out the measurements described below.

What measurements will be taken?

Preliminary measures

An individual in the research team will measure your height, weight, estimate your body fat percentage using skin fold calipers.

Blood sampling

On the same occasion, a single 10mL blood sample will be obtained from a vein in your arm by a trained investigator. The blood sample will then be analysed for markers to describe your health profile. More information on these markers can be found attached to this information sheet.

What are the possible disadvantages and risks of taking part?

The collection of blood samples can cause short-lived discomfort or minor bruising but all samples will be taken by trained phlebotomists while adhering to best practice to minimise these risks.

What are the possible benefits of taking part?

If you decide to participate in further testing you will receive individual feedback with information on your personal physiological profile that will help you in maintaining good health. As a serving firefighter it is important to maintain a good standard of fitness to be safe operationally and for good overall health. The results of the survey and obtained blood samples will enable Fire Service Health and Fitness Advisors to give advice appropriate to firefighters and better recognise behaviours detrimental to firefighter health and fitness.

What if something goes wrong?

If you have any concerns about any aspect of the way you have been approached or treated during the course of this study, please contact Dr James Bilzon, University of Bath.

If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone's negligence (but not otherwise), then you may have grounds for legal action but you may have to pay for this.

Will my taking part in the study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential. Once a blood sample is obtained and analysed, all information that will link it back to you will be destroyed.

What will happen to the results of the research study?

We will combine your results with those of other Fire & Rescue Service employees and it will not be possible for Fire & Rescue Service staff to identify your results. Data obtained from this research will contribute to the writing of national health and fitness guidance document that will be made available free of charge to the UK Fire and Rescue community. You have right of access to your records at any time.

Who is organising and funding the research?

The research is funded by FireFit, The Chief Fire Officers Association (CFOA), The Fire Research and Training Trust (FRTT) and the University of Bath. Philip Turner, a firefighter from Lancashire Fire and Rescue, Richard Stevenson of South Wales Fire and Rescue and Andrew Siddall, a research officer from the University of Bath will be organising the research.

Who may I contact for further information?

If you would like more information about the research before you decide whether or not you would be willing to take part, please contact:

Dr James Bilzon
Head of Department
Department for Health
University of Bath
Tel. 01225 383174
j.bilzon@bath.ac.uk

Thank you for your interest in this research.

Appendix. F – Participant consent form



CONSENT FORM

Project title

Assessing the health and lifestyle of the UK Fire and Rescue Service

Please read the following carefully and circle either 'yes' or 'no':

- | | |
|---|----------|
| • The nature, aims and risks of the research have been explained to me. | Yes / No |
| • I have read and understood the Participant Information Sheet. | Yes / No |
| • I understand what is expected of me. | Yes / No |
| • I understand that I can withdraw from the study at any time without giving a reason | Yes / No |
| • I understand that if I do withdraw it will not affect my Fire & Rescue Service career in any way. | Yes / No |
| • I understand that participating in this study is not part of my Fire & Rescue Service fitness assessment process. | Yes / No |
| • I consent to the processing of my personal information for the purposes of this research study. | Yes / No |
| • I understand that my information will be treated as strictly confidential in accordance with the Data Protection Act 1998. | Yes / No |
| • I understand that my any part of the Fire & Rescue staff will not have access to my individual results. | Yes / No |
| • I am aware that my consent is specific to this study and this study only | Yes / No |
| • I agree to volunteer as a subject for the study described in the information sheet and I give full consent to my participation in this study. | Yes / No |

Participant's Statement:

I (insert name)

agree that the research project named above has been explained to me to my satisfaction and I agree to take part in the study. I have read both the notes written above and the Participant Information Sheet about the project and understand what the research study involves.

Signed **Date**

AUTHORISING SIGNATURES

The information supplied above is to the best of my knowledge and belief accurate. I clearly understand my obligations and the rights of research participants, particularly concerning recruitment of participants and obtaining valid consent.

Signature of Principal Investigator

Signed **Date**

Name and contact details of Principal Investigator:

Dr James Bilzon
Head of Department
Department for Health
University of Bath
Bath, BA2 7AY
Office: 01225 383174 Email: J.Bilzon@bath.ac.uk

Appendix. G – Pearson correlation coefficients between inflammatory biomarkers and lipids.

Variable	CRP	IL-6	TNF-a
CRP	-	-	-0.08
IL-6	0.51**	-	-
TNF-a	-	-0.05	-
TC	0.10	0.05	0.05
HDL-C	-0.19*	-0.05	-0.35**
LDL-C	0.12	-0.03	0.21**
TC/HDL-C	0.11	0.11	0.19**
LDL-C/HDL-C	0.19*	0.01	0.36**
TG	0.04	0.23**	-0.06
NEFA	0.09	0.16*	-0.19**

Denotes significance at the *p<0.05 and **p<0.01 level.

Appendix. H - Pearson correlation coefficients between respondent body composition, inflammatory biomarkers and lipids.

Variable	WC	BMI	WHtR	BF%	FM
<i>Inflammatory biomarkers</i>					
CRP	0.23**	0.25**	0.20**	0.25*	0.30**
IL-6	0.18*	0.18*	0.16*	0.30**	0.22**
TNF-a	0.18*	0.19*	0.11	0.09	0.19*
<i>Lipids</i>					
TC	0.18*	0.15*	0.17*	0.19**	0.20**
HDL-C	-0.34**	-0.38**	-0.26**	-0.08	-0.28**
LDL-C	0.25**	0.18*	0.18*	0.13	0.19*
TC/HDL-C	0.21**	0.18*	0.18*	0.14	0.20**
LDL-C/HDL-C	0.35**	0.38**	0.26**	0.15*	0.31**
TG	0.11	0.26**	0.18*	0.22**	0.24**
NEFA	0.03	-0.07	0.10	0.04	-0.03

Denotes significance at the *p<0.05 and **p<0.01 level.